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THE ACTION OF SCHUMANN RAYS ON LIVING ORGANISMS

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(WITH FOUR FIGURES)

The effect of light upon organisms is a subject of steadily growing interest and importance. The work of recent years indicates that we may hope to discover the fundamental principles involved in the action of light on protoplasm more readily by turning attention to the shorter light waves than by continuing to investigate the action of the longer waves which occur in sunlight. The chief reason for this is that light of shorter wave lengths acts more rapidly and produces chemical and structural changes in such a way that its action can be much more readily followed. While these changes may not be identical with those produced by light of longer wave lengths, it may be taken for granted that the knowledge gained by studying the effects of the shorter light waves will prove to be of the greatest assistance in explaining the action of the longer waves.

The present paper is a report of some observations by the writer on the effects upon protoplasm of light in the Schumann region of the spectrum, the region containing wave lengths between 2000 and 1250 Ångström units. This region of the spectrum is of particular interest because the light which it contains has a much more injurious action upon protoplasm than has the light of longer wave length.

No previous investigations have been made of the effects upon protoplasm of light in this region of the spectrum.[1] One reason for this is that the employment of Schumann rays presents many difficulties. A special technique is required, and sources of these rays suitable for biological investigations have been lacking. The investigations on Schumann rays described in this paper were made possible by the kindness of Professor THEODORE LYMAN, who placed at the disposal of the writer the necessary apparatus and pointed out the methods by which the difficulties of technique might be surmounted.

The effects of ultra-violet light upon a variety of organisms have been studied and an attempt has been made to follow as carefully as possible the changes produced in the protoplasm. The changes in structure have been followed by observing the organisms under the microscope during the action of the ultra-violet light. The comparative efficiency of waves of various lengths in producing these changes has been studied by a variety of methods.

As previously stated, it has been found that Schumann light is much more injurious to protoplasm than any light heretofore reported. An exposure of only a few seconds to the light from a comparatively feeble source is sufficient, not only to bring about death, but also to cause a complete disorganization of the protoplasm. It has further been found that the destructive action is not lessened when the organism is exposed while it is thoroughly desiccated and in a high vacuum. As will be pointed out later, this fact is significant, for it indicates the direction in which we must look for an explanation of the changes produced by these and other electromagnetic waves.

While no record of previous investigations of the biological effects of Schumann rays has been found, it seems advisable to give a brief review of certain investigations relating to the biological effects of light of longer wave lengths.

Taking sun baths for hygienic purposes is a very ancient and widespread practice. The *heliosis* and the *insolatio* were

[1] BILLON-DAGUERRE (Compt. Rend. **149** and **150**: 1909) claims to have sterilized liquids by the Schumann rays. He made no study of the biological effects of the rays, and, moreover, it is by no means certain that his results were due to the action of Schumann rays. On this point see LYMAN (**28**).

important features of the public baths of the Greeks and the Romans.

In the beginning of the nineteenth century VALLET (33) reported a complete cure of a case of dropsy by exposing the patient to sunlight one hour each day for 14 days, and LÖBEL (24) cured a case of amaurosis by focusing sunlight upon the diseased eye. LÖBEL thought that the beneficial effects of the exposure were due, not only to the physical action of the heat and the light, but also to the chemical action of the sunlight.

In 1858 CHARCOT (9) reported the experiences of two chemists who were using an electric arc for vitrifying certain materials. The electric current was obtained from a Bunsen pile of 20 elements. The experiment lasted one and one-half hours. The experimenters were 50 cm. from the arc, and experienced no change in temperature, but their eyes pained them so severely the following evening and night that they were unable to sleep. The next day they had a painful erythema of the skin. CHARCOT cites other cases of electric light burn caused by an arc from a battery of 600 Bunsen elements. He concluded that the erythema was due to the chemical action of the light, and not due to the heat.

The first impetus to a critical study of the destructive action of light came when the germ theory of disease had been thoroughly established and scientists had recognized the importance of discovering efficient methods of disinfection. In 1877 DOWNES and BLUNT (10) reported the results of their experiments on the effect of light upon bacteria and other organisms. They undertook an investigation to determine whether or not light has a deleterious effect upon bacteria. They exposed culture media contained in glass tubes to sunlight. They showed that light is inimical to and, under certain conditions, may wholly prevent the development of organisms which are prone to appear in culture media. The action is more energetic upon bacteria than upon mycelial fungi. The fitness of the substratum for growing bacteria is not impaired by insolation. By using colored screens they showed that the blue end of the spectrum is more active than the red end. In a second paper (11) they showed that light will kill organisms which are in distilled water, and organisms which are air-dried. They tried to

approach the problem of the mechanism of the light action by studying the action of light upon organic substances. The study of the action of light upon oxalic acid showed that by insolation oxalic acid is decomposed into carbon dioxide, carbon monoxide, and water. They found that oxygen is necessary for this decomposition. Experiments were then conducted on the action of light upon ferments. They showed that light, in the presence of oxygen, destroys the power of yeast to ferment sugar. They had intended to make an exhaustive study of the action of light upon organic compounds, but CHASTAING preceded them, showing that many organic substances were oxidized by the light when in the presence of free oxygen.

DUCLAUX (15) in 1885 studied the action of light upon the anthrax bacillus. He was the first to study the action of light upon pure cultures of bacteria. He found that the ability of the organisms to resist the action of the light varies with the species, with individuals within the species, and with the nature of the culture medium.

In 1887 ROUX (30) found that his culture media, when exposed to sunlight, became toxic to the spores of the anthrax bacillus. DUCLAUX had previously shown that carbohydrates are easily oxidized in sunlight. ROUX concluded, therefore, that his culture media were rendered antiseptic by the oxidation of the carbohydrates which they contained.

WARD (34) in 1892 separated the action of the light upon the medium from the action of the light upon the organism by exposing the spores in a thin film on glass and then adding agar. The exposed spores were killed. In other experiments he first exposed the agar to the light, and then added it to thin films of unexposed spores on glass. The unexposed spores grew in the exposed agar. He attributed the action of the light to the destruction, in the presence of oxygen, of fatty foods stored in the spores. WARD in later papers (35, 36, 37) described experiments on the relative toxicity of the various parts of the spectrum. Instead of exposing culture tubes to various parts of the spectrum, as several observers had done before, he exposed a culture evenly charged with organisms (*Bacillus anthrax* and *B. subtilis*) to the spectrum, formed by a

quartz prism, of the light from a carbon arc. He was unable to tell exactly where the effect began, but in general it began at the blue end of the green, reached a maximum in the violet end of the blue, and diminished again in the violet and ultra-violet. The action extended into the ultra-violet. The culture was cooled on ice during the exposure. WARD suggested that light from a naked arc might prove efficient in disinfecting hospital wards, railway carriages, or other places where rays can proceed directly to the organism. He pointed out that a study of the action of light upon cells might teach us much concerning sunburn, sun baths, etc.

Thus far the use of light as an agent for disinfection had not proved practicable, and interest in the destructive effects of light was becoming purely academic, but the subject received a new impetus by the discovery of phototherapy. In 1871 two papers appeared in the *Lancet*, one by BARLOW (**2**), the other by WATERS (**38**), on the deleterious effects of light in the treatment of smallpox. In 1893 FINSEN (**16**) published a paper in which he reviewed the work of CHARCOT, WIDMARK, and HAMMER. A little later he published a second paper on the treatment of smallpox cases in the absence of the chemical rays (**17**). This paper was followed shortly by three others on the same theme, and later in the same year by a paper concerning the destructive action of chemical rays upon animal organisms (**18**). FINSEN'S work, published in 1893, was entitled *Negative phototherapy*.

In 1896 there was held in Copenhagen a meeting of university professors and influential laymen for the purpose of studying the value of light in the treatment of disease. At this meeting FINSEN read a paper entitled "Om Anvendelse of koncentrerede, kemiske Lysstraaler i Medicinen" (Kopenhagen, 1896), which set forth what he called "positive phototherapy," as opposed to his "negative phototherapy" of 1893. As a result of this meeting the "Finsen Medicinske Lysinstitut" was founded. The personnel of the institute consisted of 7 doctors, a physicist, an electrician, and 33 nurses. The results of the research of the institute from 1900 to 1907 were published in the *Mitteilungen* of the institute.

The basis of "positive phototherapy" is given by BIE, a member of the institute, in a paper published simultaneously in medical

journals in England, America, Germany, and France (**3, 4, 5, 6, 7**). The experimental basis of FINSEN's phototherapy is (1) the bactericidal property of the chemical light waves; (2) the power of the chemical rays to produce erythema; (3) the power of the chemical rays to penetrate the skin. The bactericidal property of the chemical rays had been demonstrated by previous workers. WIDMARK had proved by experiment the fact, pointed out by CHARCOT 30 years before, that photoerythema is produced by the chemical rays of light and not by the heat rays. GOODNEFF and FINSEN demonstrated the powers of chemical rays to penetrate the skin, by placing sealed glass tubes containing silver chloride under the skin of cats and of dogs and exposing to light. The silver chloride was blackened. FINSEN also showed that light will penetrate bloodless tissue, but will not penetrate tissue containing blood. He placed strips of sensitive paper on one side of a man's ear and allowed blue and violet rays of concentrated sunlight to fall upon the other side of the ear. After 5 minutes the sensitive paper was not affected, but if the blood was forced out by pressing the ear between glass plates, the paper was blackened in 20 seconds. In agreement with this is the fact that the spectrum obtained by passing light through an ear filled with blood consists of only a red stripe, while the spectrum obtained by passing light through an ear made anemic consists of all colors.

It is worth while to consider in some detail the method used in the practice of FINSEN's phototherapy. A carbon arc, carrying 50–60 amperes, is used as a source of light. Previous to 1901 sunlight which had passed through a concentration apparatus was used for treating the patients. Its use was abandoned because, aside from the uncertainty of weather conditions, it was found that sunlight is not only weak in the extreme ultra-violet region (the therapeutically effective part of the spectrum), but it contains an abundance of light in the blue-violet region. The blue-violet waves so tan the skin that after one or two treatments the deposit of pigment makes further treatment impossible. The carbon arc, on the other hand, emits light of shorter wave lengths than those found in sunlight. These short light waves have a marked action upon the surface layers of the skin. They destroy many of the epidermal

cells, including those which contain the pigment. The skin, therefore, becomes more transparent with each successive exposure, and hence there is a continual increase in the penetration of the light.

Experiments were made with light sources which emit a relatively greater amount of light in the extreme ultra-violet than is emitted by the carbon arc; but it was found that there was no increase in the therapeutic effects, while there was an undesirable increase in the amount of destruction of the epidermal cells (**29**).

The therapeutically effective rays are those which have wave lengths between 4000 and 3220 Ångström units. These rays, after passing through a layer of skin 4 mm. thick, have a strong destructive action upon bacteria. Light of wave lengths shorter than 3220 Ångström units has no action upon bacteria which lie beneath the surface of the skin (**23**).

The light from the carbon arc is passed through a concentration apparatus provided with condensing lenses of quartz, and also with water filters for absorbing the heat rays. The area to be treated is made as nearly bloodless as possible and is exposed to the light for 1 hr. and 15 min. at intervals of 1–3 days. The local anemia is produced by pressing the area during the exposure with a quartz lens. In certain skin diseases, notably *Lupus vulgaris*, the light treatment is so successful that out of 350 cases treated previous to 1899 there were none which did not show improvement, and only 5 which were not cured. The result is so certain and so constant that there is every reason to doubt the accuracy of the diagnosis of *Lupus vulgaris* when the method fails.

Besides developing "positive phototherapy" to a high degree of perfection, the studies carried on at the Finsen Institute contributed a large amount of information to our general knowledge of the destructive action of light. The experiments of previous investigators were carefully repeated and their significance was critically discussed, while extended researches were made into new fields.

As pointed out by LÖBEL long ago, the biological effects of exposure to light are the result of photochemical action. Hence if we are to obtain a clear understanding of the biological action of ultra-violet light, it will be necessary to consider some of the characteristics of photochemical reactions.

Photochemical action necessitates light absorption, although all light absorption is not accompanied by photochemical action. Since, for substances in general, light absorption increases as the wave length decreases, chemical action also increases as the wave length decreases; and, as pointed out in the pioneer work of DOWNES and BLUNT, the destructive action of light upon protoplasm increases as the wave length decreases.

There is evidence for the supposition that the chemical characters of some of the elements are changed when they are acted on by ultra-violet light. For example, when oxygen is acted on by light of short wave length ozone is formed; that is, ozone is more stable in such oxygen than it is in ordinary oxygen. In passing, it may be pointed out that this fact is of particular interest to the biologist, for ozone is more opaque to short light waves than is molecular oxygen, and it seems that life on earth is possible only because the ozone formed in the upper layers of the atmosphere by the ultra-violet of sunlight serves as a light-filter and protects the organisms on the surface of the earth from these shorter and more destructive rays. Chlorine may be mentioned as another example. In this case, not only are the chemical characters of the atom changed, but according to TRAUTZ (**32**) the specific heat as well.

In consequence of the fundamental nature of the changes produced by the light, it is often found that many compounds containing the same element are photosensitive. For example, light affects many of the compounds containing silver. Protoplasm contains many photosensitive elements, and it is found that protoplasm and a large number of the substances elaborated by protoplasm (sugar, starch, cellulose, chitin, hair, rubber, etc.) are decomposed when exposed to ultra-violet light.

The temperature coefficient of light reactions is very low. For photochemical reactions, therefore, temperature has but little influence upon the speed of the reaction. Photochemical changes may take place in dry materials or in a vacuum. The writer has found that the time required to kill spores of fungi was the same, whether the spores were exposed while in a very high vacuum or while in the air and turgid with imbibed water. This result is most

surprising in view of what we know of biochemical reactions, all of which take place in aqueous media.

DREYER and HANSSEN (**14**) showed that albumins and globulins were coagulated when exposed to ultra-violet light, and the writer (**8**), by an investigation of the temperature coefficient of the reaction, showed that light coagulation, like heat coagulation, involves two reactions: (1) a chemical change in the albumin and (2) the precipitation of the albumin. He showed that the first reaction has a very low and the second a high temperature coefficient.

HENRI (**19**) determined the coefficient of absorption of egg white and found that there is a close parallelism between the absorption by the albumin of the various wave lengths and their destructive action.

A very important phase of the biological effects of light is to be found in connection with the action of the so-called photodynamic substances. The reader is referred to a summary of this subject by TAPPEINER (**31**), as space does not permit a discussion of it here.

The writer has found no published record of previous investigations on the visible effects of the Schumann rays upon protoplasm. Several investigators, however, have made microscopic studies of the visible changes produced in protoplasm by light of longer wave lengths. For the most part such studies have dealt with the effects produced in the tissues of higher organisms, and secondary physiological changes have not been sharply distinguished from the immediate effects of the light. DREYER (**12, 13**) and HERTEL (**21, 22**) have studied the visible effects of ultra-violet light upon unicellular organisms, but neither of these investigators used light which contained the Schumann rays.

In the writer's investigations, described later, the visible effects of light containing the Schumann rays have been studied. The source of light was a hydrogen discharge tube similar to the one described by LYMAN (**25**). The tube had two compartments connected by the internal capillary *D*, fig. 1. This capillary had an internal diameter of about 3 mm. In each compartment there was a ring electrode (*A*) of aluminum. The discharge passing between the electrodes was compressed in the capillary *D*, thus becoming a source of light. The bottom of the tube was closed by the plate *F;*

the top was closed by a transparent fluorite plate *E*. The Schumann rays were emitted through this fluorite plate. As will be seen from the figure, the tube was so designed that the internal capillary was brought as near the fluorite window as possible without excessive heating of the window. This arrangement made it possible to expose the organism very near to the source of light. The discharge tube was excited by a ½-kilowatt transformer manufactured by the Clapp Eastham Company. The transformer worked on a 110-volt alternating circuit of 60 cycles. A variable resistance in the primary circuit was adjusted so that about 0.8 ampere flowed through the primary of the transformer. The current through the discharge tube was 16–18 milliamperes. No capacity, beyond that due to the leads, was included in the discharge tube circuit.

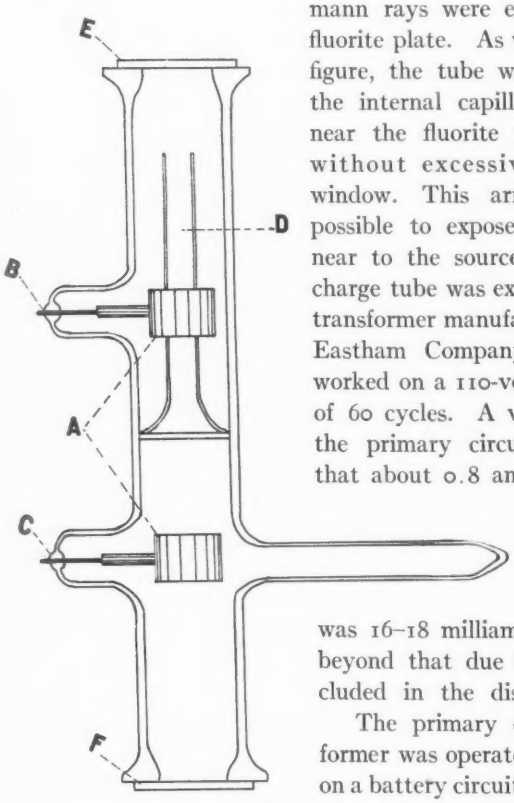

FIG. 1.—Discharge tube used for generating Schumann rays: *A*, ring electrodes of aluminum; *B*, *C*, terminals connecting with a source of high potential (*E*, *M*, *F*); *D*, capillary for increasing the current density; *E*, fluorite window; *F*, glass window.

The primary circuit of the transformer was operated by a relay working on a battery circuit which was controlled by an ordinary telegraph key. The relay circuit had connected with it another circuit which moved the pens on a chronograph. From the chronograph record the exact length of any exposure could be determined. The use of the relay circuit and telegraph key made it possible to operate the discharge tube without the risk of coming in contact with lines carrying currents of higher voltages. This was important when the

tube was used in connection with a compound microscope, for it was often desirable not to look away from the microscope while operating the discharge tube.

The discharge tube was placed upright under the stage of a compound microscope, in the place usually occupied by the condenser and other substage attachments, with the fluorite window flush with the upper surface of the microscope stage. When the discharge tube was in this position the microscope mirror could not be used. Hence it was necessary to illuminate the objects under observation by some other means. Various methods were employed: an arc lamp was placed beneath the work table, and by means of mirrors and lenses a beam of parallel light was directed up through the discharge tube; or the objects were lighted from above, either by concentrating the light on the microscope stage with a condensing lens or by using a special vertical illuminating objective.

The discharge tube was held by a mechanical support so arranged that by moving a lever the discharge tube moved down and away from the microscope stage. The regular substage attachments could then be swung back into operating position. The change from the discharge tube to the substage attachments or from the substage attachments to the discharge tube could be made very quickly, and without interrupting observations through the microscope.

The Schumann region of the spectrum is a region of general absorption for most substances. But few solids are known which transmit even the longest Schumann waves (**26**). Air absorbs all except the longer waves, the absorption being due to the oxygen (**27**). Fluorite is the only substance known which transmits the entire Schumann spectrum. In fact, the Schumann spectrum extends in the direction of short wave lengths only as far as fluorite transmits. It is evident, therefore, that if we wish to expose organisms to the entire Schumann spectrum we can have no substance other than fluorite between the organism and the source of light. Even air must be displaced by the more transparent fluorite. Occasionally the organisms were placed directly on the fluorite window of the discharge tube; more often a special slide was used. The special

slide was a regular microscope slide with a hole 1.5 cm. in diameter bored through it. A disk of fluorite was cemented into the hole with its upper surface flush with the upper surface of the slide. This slide was held in the regular mechanical stage of the microscope and the fluorite window of the discharge tube was thus brought into contact with the fluorite disk in the slide.

When the tube was excited for any great length of time it became hot, and sufficient heat was conducted to the microscope slide to vitiate the results. It was found, however, that the light was so destructive that during a single exposure of sufficient length to kill the organisms, the temperature did not increase more than 1° C. The discharge tube was moved away from the microscope slide immediately after each exposure. The temperature of the drop of water which contained the organisms was measured by means of a thermal junction made of copper and constantin. The sensitiveness of the galvanometer used was such that, with these junctions, one division on its scale corresponded to 0°.05 C. The constant junction was kept packed in ice in a thermos bottle. The variable junction was flattened out very thin and was attached to a flexible support in such a manner that it could be placed beside the organisms under the cover glass. The junction was held in place on the slide by the capillary pressure of the cover slip, and was in the field of view of the microscope during the entire experiment. If the temperature of the drop of water was raised more than 1° C. by the exposure to the light, the experiment was discarded. The arrangement of the tube, slide, and thermal junction is shown in fig. 2.

The length of time required for killing varied both with the species and with the individual organisms. In general, a small organism was killed more quickly than a large one. With a given light intensity, an exposure of several minutes was not sufficient to kill such organisms as rotifers and lumbricoid worms, while *Sphaerella*-like swarm spores, which contain both chlorophyll and an "eye spot," were killed almost instantly. The swarm spores were killed so quickly that there was not sufficient change in temperature to be indicated by the thermal junction. In some of the experiments the intensity of the light was reduced until an exposure

of 10 seconds was required to kill the swarm spores. Exposures of one second duration were then made at intervals of several seconds. It was found that the action of the Schumann rays is additive. The swarm spores were killed only when the total exposure equaled 10 seconds. Other organisms gave similar results. The fact that the action of the light is additive made it possible to interrupt the exposure from time to time, and to make a detailed study of the progress of the changes produced by the light. The protoplasm of the swarm spores which had been killed by the light had a granular appearance. Often some of the protoplasm was extruded from the cells and was rounded up into drops.

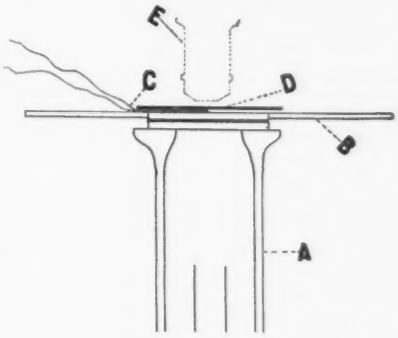

FIG. 2.—Arrangement of apparatus for microscopic observation of the effects of Schumann rays: *A*, discharge tube; *B*, microscope slide containing a fluorite window; *C* thermal junction; *D*, cover glass; *E*, microscope objective.

The cells of a large *Spirogyra* of the *crassa* type were killed by an exposure of 45 seconds when the discharge tube was carrying 18 milliamperes. The first visible change was the disappearance of the wavy margin of the chlorophyll bands. This began on the side of the cell nearest the light. Later the bands broke into isolated rounded drops, each drop containing a pyrenoid. At the same time that the bands were breaking up, they became shorter and contracted around the nucleus. As they contracted, they moved away from the cell wall, pulling the protoplasm lying next to the wall out into threads of viscous appearance. The nucleus became swollen and distended.

When an active amoeba was exposed to the light of the hydrogen discharge tube there was a momentary cessation of motion, followed by a withdrawal of the advancing pseudopodia. Locomotion in another direction began again at once, before the pseudopodia were entirely withdrawn. The extended pseudopodia often turned directly upward away from the light of the discharge tube, and

usually a pseudopodium was sent upward from the upper surface of the body. This pseudopodium was often seen to flatten out against the cover slip. The nucleus moved up into the upper part of this pseudopodium. In some cases so much of the protoplasm flowed up into the pseudopodium that the amoeba became top-heavy and toppled over. One amoeba was seen to send up a pseudopodium, to fall over, and then to repeat the process three times before it was killed. These reactions are really negative phototropic responses, the amoeba moving upward away from the light.

As the protoplasm flowed up into the vertical pseudopodium a thick hyaline ectoplasm was left below. The ectoplasm usually constituted the greater part of the lower half of the amoeba. Often the amount of ectoplasm increased until it nearly equaled the amount of endoplasm. In one case the cover glass was pressed down on an amoeba while in this condition, and the endoplasm and the ectoplasm separated and rounded up into separate drops. Under a magnification of 2200 diameters the ectoplasm showed a few small granules in Brownian motion, but showed no vacuoles. After a prolonged exposure there was often a peculiar flowing of the granular endoplasm out into the ectoplasm. It did not appear to be the same kind of motion that one observes in the regular streaming of the protoplasm, but it was not easy to say wherein the difference lay. After this all motion ceased and the protoplasm appeared coagulated. Under a high magnification (2200 diameters) the protoplasm was seen to be filled with fine vacuoles which were so numerous that it was converted into a fine froth. These vacuoles were not visible before the organism was exposed to the light.

It often happened that only a part of an amoeba was killed; for example, in one case an amoeba which happened to be near a bit of opaque substance when the exposure was made sent a pseudopodium up on top of the opaque substance. The nucleus was next sent up, and then as much of the granular protoplasm as possible. The bit was not large enough to protect the whole organism, and a fringe of protoplasm (ectoplasm) extended beyond it all the way around. The exposure was continued until this fringe was killed. After the exposure, the unexposed part of the organism moved away, leaving the dead fringe behind. In another case the light

was allowed to act for a few seconds on an amoeba which was moving very rapidly across the field of the microscope. The amoeba became quiet during the exposure. As soon as the light was turned off, motion was resumed, but only part of the amoeba moved away; a part of the protoplasm was coagulated and was left behind. The exposure was continued in this way, a few seconds at a time, killing a part of the amoeba at each exposure, until only the nucleus and a small mass of surrounding protoplasm remained alive. A final exposure killed this. The length of exposure necessary to bring about these changes varied from 30 to 100 seconds with the hydrogen discharge tube carrying 29 milliamperes. As previously stated, the entire exposure was not made at one time, but at intervals, so that the experiment often extended over an hour. The changes produced by the light could thus be more carefully observed.

Infusoria are very quickly cytolyzed by the rapid vibrations of these ultra-violet rays. The nature of the cytolysis varies greatly with the species, and in some of the minor details it varies with the different individuals. The writer has observed three kinds of photocytolysis in ciliated infusoria: (1) a cytolysis which is accompanied by the formation of vesicles on the surface; (2) a cytolysis in which some of the internal portions of the protoplasm coagulate; and (3) a cytolysis in which some protoplasm disintegrates directly. The first two types of cytolysis were observed in *Colpoda*-like forms, and the third type was observed in *Stylonychia*.

1. *Cytolysis by the formation of vesicles.*—The cytolysis is, in general, like that of *Paramoecium* in distilled water, in weak alkali, and in 5 per cent alcohol, as described by WULZEN (**39**). When a *Colpoda*-like infusorian is exposed to the light from the discharge tube carrying 18 milliamperes there is first an increase, then a decrease, in the rate of motion of the organism. Soon vesicles filled with a clear liquid begin to form on the surface of the animal. The infusorian loses its original shape and swims in circles. A vesicle may continue to grow until it is larger than the original organism, or it may increase in size for a short time and then slowly shrink and disappear. As one vesicle is shrinking, others may be forming at some other part of the surface of the organism. If the exposure is

not continued too long the vesicles may entirely disappear and the organism apparently recover. A longer exposure causes the inner wall which separates the organism from the vesicle to rupture and the protoplasm to flow out into the vesicle; while a still longer exposure may cause the outer wall of the vesicle to rupture, permitting the protoplasm to flow out into the surrounding water, with which it is miscible. Sometimes the protoplasm disorganizes and rounds up into drops before it flows into the vesicle. This type of photolysis requires a total exposure of about 30 seconds.

2. *Cytolysis in which parts of the protoplasm coagulate.*—In this type of cytolysis an exposure of 10 seconds causes small areas of the protoplasm to coagulate. The coagulated masses move to the side of the organism and are extruded at once. A longer exposure causes more masses of coagulum to form. As the exposure continues, the masses of coagulum form faster than they are extruded. A swelling appears on one side of the body, which increases in size and then bursts, allowing the protoplasm to flow out into the surrounding water.

3. *Cytolysis in which the protoplasm disintegrates directly.*—When *Stylonychia* is exposed to the light from a hydrogen discharge tube excited by a current of 18 milliamperes, the organism is stimulated and its rate of motion is increased. It then loses its power of coordination, moves about in circles for a time, and finally comes to rest with its cilia still vibrating. Suddenly the outer membrane breaks at some point and a little protoplasm squirts out. Then, starting from this point, a wave of disintegration passes over the organism, leaving the protoplasm in isolated rounded drops. The drops show surface tension against each other, and also against the fluid in which they lie; but a further exposure may cause some of them to unite. If the discharge tube is excited by a stronger current, 50–70 milliamperes, the cytolysis begins at once before the loss of coordination occurs. Cytolysis begins at the posterior end of the organism. The infusorian darts across the field, leaving behind it a trail of its cytolyzed protoplasm. It continues its motion until only a very small amount of the original protoplasm remains intact, and this cytolyzes at the instant motion ceases.

When the dry spores of *Monilia* sp. are exposed to the light no visible change is observed. If, however, after exposure the spores are allowed to absorb water they become turgid, but their protoplasm assumes a coarsely granular, coagulated appearance, which is quite different from the finely punctate appearance of turgid unexposed spores. When turgid spores of *Monilia* are exposed to the light two kinds of changes are observed: either the protoplasm takes on a coagulated appearance, after which no further change is seen, or the spore wall suddenly bursts and some of the protoplasm squirts out with such force that the spore is driven backward by the reaction. The protoplasm, both outside and inside the spore wall, appears granular. Approximately 50 per cent of the turgid spores burst in this manner when exposed to the light. An exposure of 20 seconds, when the discharge tube is carrying 18 milliamperes, is required to cause the spores to burst. A similar squirting out of the protoplasm was observed in a *Navicula*-like diatom, and in the spores of certain water molds when they were exposed to the light.

The fact that the light acts directly upon the organism itself, and not indirectly through the formation of some toxic substance in the medium, was made evident in the experiments in which the drop containing the swarm spores was larger than the window of the discharge tube, so that a few of the spores which were on the outer edge of the drop were not exposed. Those swarm spores which were not exposed to the light were not killed, even though they were at the very edge of the illuminated area. When the exposure was over they often swam into the region where spores had been killed the instant before. As they entered this region they did not make any change either in the rate or in the direction of their motion. From this it may be concluded that the light did not produce any toxic substance in the solution. This conclusion is further strengthened by the fact that occasionally a swarm spore which was within the range of the light from the discharge tube was protected from the direct influence of the light by the shadow of some opaque material contained within the drop. No change which could be attributed to the action of the light was observed in such an individual. Again, the fact that the position of the dead swarm spores

always marked out exactly the outline of the window of the discharge tube may be taken as evidence that no toxic substances were formed in the solution. The observations made on other species of organisms lead to the same conclusion, that the action of the light is on the organism itself.

Notwithstanding the fact that the light was from an exceedingly feeble source, the changes in the organisms were immediate. In the small swarm spores with thin transparent cell walls the changes appeared the instant the discharge tube was excited. It is evident that the Schumann rays are very destructive to protoplasm. The examples just given of the visible effects of these rays upon organisms are sufficient to make it apparent that we are dealing here with a powerful cytolytic agent, and one which warrants further study.

The relation between the wave length and the destructive action of light in the Schumann region of the spectrum has not been previously studied. For the longer light waves this relation has been investigated to some extent, as will appear from the brief summary which follows.

DOWNES and BLUNT, using colored screens, showed that blue light is more destructive to bacteria than red light. WARD, using a quartz prism, confirmed the results of DOWNES and BLUNT, and showed that the killing power extends into the ultra-violet.

Two papers appeared in 1905 on the bactericidal action of light, describing experiments in which not only the wave length but also the intensity of the light was measured. BANG spread the light of a carbon arc into a spectrum by means of quartz lenses and a quartz prism, and measured the relative destructive action of the various parts of the spectrum by determining the length of time it took in a given region of the spectrum to kill an organism (*Bacillus prodigiosus*) growing on the surface of an agar plate. His results showed that, in general, as the wave length of the light decreases the destructive action increases, but that the curve is not uniform, showing a break in the region of wave length 3000 Ångström units. In this region the light is several hundred times less destructive than in the regions on either side, so that the curve shows two maxima. The secondary maximum is in the region of wave length 3500

Ångström units. A measurement of the energy of the spectrum (which was made with a bolometer) showed that the amount of energy decreased with the decreasing wave length; but that in a region nearly coinciding with the region in which the destructive action of the light fell off the amount of energy increased, so that, when the two curves, the energy curve and the destructive curve, are compared, the one is seen to be the inverse of the other. The depression in the destructive curve and the elevation in the energy curve do not quite coincide, but BANG attributed this to a slight shift in some part of his spectrograph.

HERTEL (**21**) used quartz lenses and a quartz prism to form a spectrum of the light from various spark gaps. He measured, by means of a thermopile, the energy of the light of various wave lengths which he allowed to fall upon living tissues. He found that the destructive action of the light varies directly as the energy, and inversely as the wave length. He did not find the two maxima described by BANG.

HENRI (**19, 20**) in 1912 measured the relative destructive action of light of various wave lengths. He used as sources of light a mercury vapor arc in quartz, and spark gaps with cadmium and magnesium terminals. The relative intensity of the light of various wave lengths was measured by the effect upon a photographic plate. He made use of screens for filtering out the various wave lengths. The efficiency of the screens was determined by spectrographic methods. He found that the destructive action of the light increases continuously as the wave length decreases. HENRI did not find a secondary maximum at 3500 Ångström units, as reported by BANG. With the exception of BANG, these investigators have agreed that, in the regions of the spectrum studied, the destructive action of light increases as the wave length decreases. None of their investigations have included the region of the spectrum lying below wave length 2000 Ångström units.

In the experiments described in this paper the relation between the wave length and the destructive action in the Schumann region has been studied. Because of the small amount of energy in the Schumann rays, no attempt has been made to measure the intensity of the light of the various wave lengths. A knowledge of the

relative intensity has been approximated from their effect on a photographic plate. It is known that the spectrum from a hydrogen discharge tube contains a number of bright lines in the neighborhood of wave length 1600 Ångström units, while if the hydrogen is extremely pure there are no lines between wave lengths 2000 and 1675 Ångström units. In this study the destructive action of light including the wave lengths in the region of 1600 Ångström units has been compared with the destructive action of light from which these waves have been filtered out by means of screens. The hydrogen discharge tube previously described was used as a source of light. Three different methods were used.

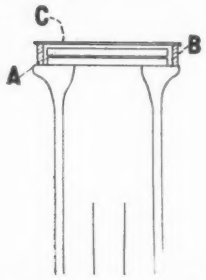

FIG. 3.—Arrangement of discharge tube for studying the relation between wave length and the destructive action of Schumann rays: *A*, rock salt screen; *B*, brass ring; *C*, cover slip.

In the first method the hydrogen discharge tube was placed upright with the fluorite window above. The rock salt screen *A* (fig. 3) was laid upon the fluorite window. Glass plates were coated with nutrient agar and set aside in a sterile closet until the agar became air dry. Spores of *Penicilliun* were placed upon the agar surface, and the plate *C* placed, spores downward, on the ring support *B*. The lower surface of the plate was about 0.05 mm. from the salt screen. After the exposure, the plates were placed in Petri dishes lined with damp filter paper and the Petri dishes set in the incubator. The agar absorbed water and the uninjured spores germinated.

Exposures of various lengths were made, and the shortest exposure which would kill determined. The amount of current flowing through the discharge tube was measured and kept constant during all the experiments. The rock salt screen cut out the light of wave lengths shorter than 1800 Ångström units (**26**). Control experiments were made by removing the rock salt screen and laying in its place a screen of fluorite having the same thickness. The fluorite was transparent to waves longer than 1250 Ångström units. By using the fluorite screen the distance between the spores and the

source of light was kept constant. The short waves would have been absorbed by the air had it not been replaced by the more transparent fluorite.

Spores of *Cephalothecium roseum* were not killed by an exposure of 60 seconds, and spores of a species of *Monilia* were not killed by an exposure of 420 seconds when the screen of rock salt was used, while the spores of both forms were killed by an exposure of 15 seconds when the screen of rock salt was replaced by the screen of fluorite.

In the two other methods the apparatus shown in fig. 4 was used. A glass tube *A*, 31 cm. in diameter, was closed at one end with a glass stopper *B* which was ground in. The other end was closed by a brass ring *C* which had a fluorite disk *D* sealed into its center. The seal was made with De Khotenski cement. A side tube *E* connected the tube *A* with a mercury vacuum pump and a McLeod gauge. The tube was used in a vertical position. An upright brass tube *F* was cemented to the glass stopper. At its upper end it carried a platform *H*. The platform was a copper disk soldered to the head of a screw *I* which passed through a nut soldered to the top of the brass tube *F*. By turning the screw the distance between the platform *H* and the fluorite window *D* could be regulated. A hemisphere *K*, 5 mm. in diameter, was pressed out of a polished platinum plate. Its open side was brazed to a small piece of brass plate *L*.

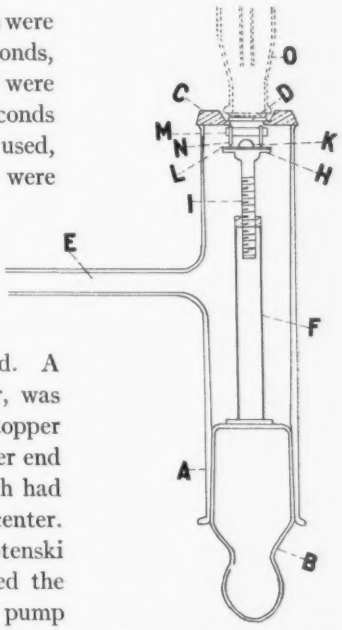

FIG. 4.—Chamber for studying the relation between wave length and the destructive action of the Schumann rays: *A*, glass tube; *B*, stopper; *C*, brass ring supporting fluorite window *D*; *E*, exhaust tube; *F*, adjustable support for the platform *H*; *K*, platinum hemisphere which is brazed to the brass plate *L*; *M*, rock salt screen supported by the brass pins *N*; *O*, discharge tube.

A disk of rock salt *M* with plane parallel faces had holes bored through it into which were inserted brass pins *N*, which served as legs. In operation, these parts were placed in the tube, as shown in the figure. The source of light was a hydrogen discharge tube, as shown at *O*. Its fluorite window was in contact with the fluorite window *D*.

In one method the apparatus was used as follows: The glass stopper with its attached parts was removed from the tube, the platinum hemisphere sterilized in a flame, and then placed convex side upward upon the stage of a binocular dissecting microscope. Fungus spores were transferred to the top of the hemisphere with a platinum needle. By means of the binocular microscope the arrangement of the spores on the platinum hemisphere could be easily observed. After the spores were transferred to the dome a current of air blown through sterile cotton was allowed to play upon the hemisphere. All of the spores which were not in actual contact with the platinum were thus removed. This treatment gave a thin layer of spores quite evenly distributed over a small area at the very top of the hemisphere. The platinum hemisphere was now placed upon the platform *H*, and the screen *M* placed in position, the glass stopper *B* inserted and carefully turned until an air-tight joint was formed. The tube was then exhausted to about 0.001 mm. mercury pressure, and the exposure made. After the exposure, air was admitted into the tube and the stopper *B* removed. The platinum hemisphere with the exposed spores was again placed on the stage of the binocular microscope. A small drop of agar had been allowed to solidify on the under side of the cover slip of a van Tieghem cell. This cover slip was removed from the cell and brought over the spores on the platinum hemisphere. Then, while observation with the binocular microscope was being made, the cover slip was carefully lowered until the "hanging drop" of agar just touched the spores on the top of the hemisphere. The cover slip was immediately lifted, taking the spores with it, and placed back on the ring of the van Tieghem cell. The cell was then set in an incubator. Because of the curved surface of the platinum hemisphere the spores were transferred to the agar without changing their relative positions, and as the agar drop came in contact

only with the spores on the top of the hemisphere, only those which had been directly exposed to the rays of light were transferred. The length of exposure required to kill the spores with and without the salt screen was determined. The results obtained with the spores of *Trichothecium roseum* are given in table I.

TABLE I

Without rock salt screen		With rock salt screen	
Time of exposure in seconds	Percentage of germination	Time of exposure in seconds	Percentage of germination
0	20.5	0	20.0
3	2.9	120	2.0
7	3.2	300	1.0
15	1.3	600	0.0
30	0.0	1200	0.0
60	0.0		
120	0.0		

An unknown amount of light was reflected from the surface of the salt screen. In order to avoid this source of error, the experiments were repeated, and the length of exposure required for killing was determined first with the tube containing air at atmospheric pressure, and then with the tube evacuated. The distance from the top of the platinum hemisphere to the fluorite window *D* was 1 cm. This gave a filtration of 1 cm. of air. LYMAN (**27**) has shown that an air filter 1 cm. thick cuts out all of the shortest Schumann rays. The results obtained with *Trichothecium roseum* are given in table II.

TABLE II

Time of exposure in seconds	Conditions	Results
7	Vacuum	Growth
15	"	"
30	"	Dead
30	Air	Growth
60	"	"
120	"	"
240	"	"
480	"	Dead

I was not able to kill the tan-colored spores of *Penicillium brevicaule* or the black spores of *Stemphylium* sp. (probably *S.*

macrosporoidium). The Schumann rays have not sufficient penetrating power to pass through the colored cell walls.

By this method we were comparing the time required to kill spores in air with the time required to kill them in a vacuum, but preliminary experiments in which the hemisphere *K* was brought very close to the fluorite window *D* showed that the presence or absence of air makes no difference in the length of exposure required for killing. It should be pointed out that for these experiments organisms were selected which had very thin and transparent cell walls. It was impossible to obtain similar results with organisms with thick, dark-colored spore walls. The length of exposure required to kill dark-colored spores was so great that it is doubtful if the Schumann rays took any part in the killing.

The light emitted from the fluorite window of the hydrogen discharge tube is much less destructive when the light waves of a length shorter than 1700 Ångström units are filtered out. The results obtained by the three methods are comparable. The light is 15–20 times more destructive when it contains the short waves than when it does not. The significance of these figures lies in the fact that in the Schumann region, as in the regions of longer wave length, the destructive action of the light increases as the wave length decreases. Necessarily, this statement does not hold true for organisms protected by membranes which are opaque to the Schumann rays.

Summary

By a number of methods it has been shown that the action of the light is on the organism directly, and not indirectly through the formation of some toxic substance in the medium.

It is a well-established fact that the Schumann region of the spectrum is a region in which nearly all substances have strong absorption bands. While no studies have been made upon the absorption of protoplasm in this region of the spectrum, undoubtedly strong absorption does occur. Gelatin, which is a much simpler substance than protoplasm, is so opaque to the rays that the ordinary photographic plate cannot be used in photographing the Schumann spectrum. Special plates, in which the silver salts

are for the most part deposited on the surface of the gelatin, must be used.

HENRI (**19, 20**) has shown that a very thin layer of egg white is opaque to ultra-violet waves between 3000 and 2000 Ångström units in length, and that in this region the opacity increases as the wave length decreases. If the absorption coefficient of egg white can be applied to living protoplasm, and if the opacity of egg white continues to increase with decreasing wave length as we pass from the region studied by HENRI into the Schumann region, then it is reasonable to suppose that the Schumann rays penetrated only a short distance into the substance of the organism. The extreme destructive action of these rays is a result of the strong absorption.

That the rays penetrate only a short distance into the substance of the organism is indicated by the observations made on amoebae, in which only a part of the protoplasm was killed by the exposure to the light. It may have been that the nucleus and the protoplasm which moved up into the vertical pseudopodium were well protected from the shortest waves of the Schumann rays by the thick layer of ectoplasm which remained below. Those parts of the protoplasm which were on the side away from the source of light were killed by the longer, less active light waves only after a prolonged exposure. Again, in the experiments on *Spirogyra*, the visible changes always began on the side of the cell nearest the light. Fungus spores, with brown or tan coloring matter in their cell walls, even though the walls were thin, were not killed by a prolonged exposure to the light. The Schumann rays could not pass through the cell wall.

Because of this strong absorption, the Schumann rays have a marked localized action which gives them a peculiar value for investigations in the experimental morphology and physiology of the cell.

In the experiments on the motile organisms, amoebae and infusoria, it was seen that the Schumann rays have a stimulating effect, to which the amoebae respond by drawing in the pseudopodia and assuming a spherical form, and to which the infusoria respond, first, by an increase in the rate of motion followed by a decrease, then by a loss of the power of coordination, and finally by the disintegration of the living substance.

The examination of highly differentiated cells like those of *Spirogyra* has shown that the visible changes produced by the light are not the same in all protoplasmic structures. The change produced is often one which results in an alteration of the equilibrium of the water content of the protoplasm, as shown by the shrinking and swelling of various parts, by the bursting of spores, and by the miscibility with the surrounding water of the protoplasm of cytolyzed infusoria.

As pointed out in a former paper (**8**), ultra-violet light causes certain chemical changes in egg albumen, changes which lead to a change in the time-temperature-coagulation curve. A study of the nature of these chemical changes has shown that they result in a decomposition of the albumen molecule. Preliminary experiments upon the effects of ultra-violet light on other protein bodies show a similar destructive action of the light. It would seem, therefore, that the stimulus of light is to be classed with those exciting stimuli which accelerate catabolic changes; and that using, as we have in these experiments, light with high vibration frequencies, we have been able within a short space of time and with no very great light intensity to carry the chemical changes through fatigue and death, and finally to a complete destruction and dissolution of the protoplasm.

The writer has found that spores dried *in vacuo* may be killed by ultra-violet light. This becomes understandable from experiments which the writer made, and which will be published later, which show that albumen and other proteins, dried *in vacuo*, are readily decomposed by ultra-violet light. The effect of these high-frequency electromagnetic vibrations on proteins is comparable to that of dry distillation at high temperature.

These experiments suggest to us a mechanism of the killing action of ultra-violet light, and furnish a clue which, it is hoped, will explain the mechanism of all the effects of light on protoplasm, including those which are not injurious; for it is evident that if the decomposition of the protein molecule is not carried too far it may stimulate the cell without producing injury. A good example of this sort of stimulation is seen in artificial parthenogenesis, which is produced by substances the action of which kills the egg if allowed

to go too far, but merely stimulates it if stopped at the right time.

It is interesting to note that the photolyses previously described follow the photo-chemical-energy law first formulated by TALBOT, that the amount of chemical change is proportional to the product of the intensity times the length of exposure, or, if the intensity is constant, that the amount of chemical change is proportional to the length of exposure. It required the same total length of exposure to bring about cytolysis when the illumination was interrupted as when it was continuous.

In the Schumann region of the spectrum, as in the regions of longer wave length, the destructive action of the light increases as the wave length decreases, and when we consider the very short exposure which was required for killing, notwithstanding the feeble source of light used, it is evident that the light of the Schumann region is much more destructive than the light of the regions of longer wave length. In other words, the curve representing the relation between wave length and destructive action, which slopes upward in the regions of shorter wave lengths, continues into the Schumann region of the spectrum without changing its character.

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WESTERN PLANT STUDIES. III

AVEN NELSON AND J. FRANCIS MACBRIDE

POLYPODIUM VULGARE L. var. **hesperium** (Maxon), n. comb.—*P. hesperium* Maxon, Proc. Biol. Soc. Wash. **13**: 200. 1900.—The intermountain form with shorter, broader, and usually very obtuse pinnae.

ISOETES OCCIDENTALIS Hend. var. **Piperi** (A. A. Eat.), n. comb.—*I. Piperi* A. A. Eat. Fern Bull. **13**: 51. 1905; *I. Howellii* Engelm. var. *Piperi* Clute, Fern Allies 258. 1905.—The velum broader and the spores larger with obtuse tubercles.

Muhlenbergia setiglumis (Wats.), n. comb.—*M. sylvatica* Torr. var. *setiglumis* Wats. Bot. King Exped. 378. 1871.—Very closely allied to the eastern *M. sylvatica* Torr., but each confined to its own range.

Streptopus streptopoides (Ledeb.), n. comb.—*Smilacina streptopoides* Ledeb. Fl. Ross. **4**: 128. 1852; *Kruhsea Tilingiana* Regel Nom. Mem. Soc. Nat. Mosc. **11**: 122. 1859; *S. brevipes* Baker, Jour. Linn. Soc. **14**: 592. 1875.—This form of species name is always to be regarded as unfortunate, but at the present time, at least, it must be used in cases like this.

Majanthemum dilatatum (Wood), n. comb.—*Unifolium bifolium* DC. var. *dilatatum* Wood, Proc. Phil. Acad. 154. 1868.—The genus *Majanthemum* is one of the *nomina conservanda* of the international rules. The plant is well worthy of specific rank.

Arenaria macra, n. n.—*A. tenella* Nutt. T. and G. Fl. **11**: 79. 1838, not Kit. in Schuet. Oestr. Fl. ed. II. **1**: 662. 1814, a valid species of Austria.

Spergularia bracteata (Robinson), n. comb.—*S. salsuginea* Fenzl. var. *bracteata* Robinson, Syn. Fl. **1**: 251. 1897.—The bractlike upper leaves are very different in aspect from the apparently entirely Siberian *S. salsuginea.*

DELPHINIUM MENZIESII DC. var. **fulvum,** n. var.—Pubescence, especially above, yellowish-villous and slightly viscid.—Eastern Oregon and adjacent Idaho.

Delphinium stachydeum (Gray), n. comb.—*D. scopulorum* Gray var. *stachydeum* Gray, Bot. Gaz. **12**: 52. 1887.—One of the most readily distinguished species of the group to which it belongs.

Meconella linearis (Benth.), n. comb.—*Platystigma linearis* Benth. Trans. Hort. Soc. II. **1**: 407. 1834; *Hesperomecon lineare* (Benth.) Greene, Pitt. **5**: 146. 1903.—Greene (*op. cit.*) has called attention to the earlier and valid *Platystigma* of Robert Brown. In our judgment, however, *Hesperomecon* Greene is not distinct from *Meconella* Nutt.

Horkelia Tweedyi (Rydb.), n. comb.—*Ivesia Tweedyi* Rydb. N.A. Fl. **22**: 288. 1908.—This plant was long included in the nearly related but much more southern *H. utahensis* (Wats.) Rydb. It is consistently distinct from that species, however, and seems to be confined to Washington on the eastern slope of the Cascades. In making this transfer we would call attention to our remarks in Bot. Gaz. **55**: 375. 1913 on the fallacy of maintaining certain segregate genera in this group.

Trifolium Kennedianum (McD.), n. comb.—*T. involucratum* Ortega var. *Kennedianum* McD. N.A. Trif. 56. 1910—The broad, equal, entire involucral teeth readily distinguish this plant. In the species to which it was referred, the involucral teeth are sometimes entire, but narrower and very unequal in length.

Cardamine cordifolia Gray var. **Lyallii** (Wats.), n. comb.—*C. Lyalli* Wats. Proc. Am. Acad. **22**: 466. 1887; *C. cordifolia* Gray subspec. *Lyallii* (Wats.) O. E. Schulz, Engl. Bot. Jahrb. **32**: 438. 1903.—Schulz is undoubtedly justified in no longer maintaining this plant as a species. We give it varietal rank that it may accord with those variations deemed unworthy of specific status, and then treated as varieties by most American botanists.

CLARKIA and its near allies.—In Bot. Gaz. **52**: 267. 1911, there were separated from *Clarkia* some species that are evidently aberrant in that genus. It is very doubtful whether the restoration of the genus *Phaeostoma* relieved a difficult situation. Granting that *Phaeostoma* has 8 fertile anthers while *Clarkia* has only 4, separating on this basis creates an equal difficulty between *Godetia* and *Phaeostoma* in that both have 8 stamens and the latter may have petals either clawed or not clawed. But the same is true

of *Godetia* if *G. biloba* Wats. be left in the genus. This latter might be transferred to *Phaeostoma* but for its bilobed petals, or to *Clarkia* if judged by its aspect alone. The larger the series of specimens and the more species included in the study, the more probable it seems that unbroken series can be established running through the three genera on the following characteristics:

1. Stamens 4–8 and all alike or in two sets, the one gradually reduced in size and finally to sterility and extinction.

2. Petals from entire to deeply 2 or 3-lobed, and from sessile to long and narrowly clawed.

It would not seem unwise to reduce all three to one genus but for the fact that to do so would again necessitate a number of new combinations.

Pachylophus psammophilus, n. sp.—Wholly glabrous throughout, caulescent, branching near the base, usually 1 dm. or more high: leaves lanceolate, entire or slightly repand, acutish, each attenuate into a petiole with margins narrower than the midrib: calyx tube only twice as long as the narrow acute segments: petals white (drying pink), 2–3.5 cm. long: capsules sessile, narrowly conical, somewhat curved and tapering gradually, 3–3.5 cm. long, not at all tuberculate, slightly angled.

Plants growing in sand dunes in the vicinity of St. Anthony, Idaho. Very distinct in aspect and technical characters from its nearest relative, *P. caespitosus* (Nutt.) Raimann, of South Dakota.

PERIDERIDIA Reichb. Handb. 219. 1837; Meisn. Genera 1:150. 1837; Endl. Gen. Pl. 792. 1838; Steudel, Nom. Bot. ed. II. 2:304. 1841.—*Eulophus* Nutt. in DC. Coll. Mem. 5:69. 1829, not *Eulophus* R. Br. in Bot. Reg. 573. 1821, in the English text.

ROBERT BROWN in 1821 published his new orchidaceous genus *Eulophus*, and though he changed this to *Eulophia* in 1823, the earlier form of the word must, of course, be used. This necessitates, unfortunately, another name for the plants we have known so well as *Eulophus* Nutt. It may be questioned if REICHENBACH really published his genus in his *Handbuch;* certainly he makes no reference to a species, as stated in the *Kew Index*. The genus is given good descriptions by the authorities cited above, however; and STEUDEL publishes it with the species. The following new combinations, together with the type, are noted.

PERIDERIDIA AMERICANA Reichb. ex Steudel, Nom. Bot. ed. II. **2**:304. 1841; *Eulophus americanus* Nutt. in DC. Coll. Mem. **5**:69. 1829.

Perideridia Parishii (C. and R.), n. comb.—*Eulophus Parishii* C. and R. Rev. N.A. Umbell. 112. 1888.

Perideridia Pringlei (C. and R.), n. comb.—*Eulophus Pringlei* C. and R. *op. cit.* 113.

Perideridia simplex (C. and R.), n. comb.—*Eulophus simplex* C. and R. Contrib. Nat. Herb. **7**:112. 1900.

Perideridia Bolanderi (Gray), n. comb.—*Podosciadium Bolanderi* Gray, Proc. Am. Acad. **7**:346. 1868; *Eulophus Bolanderi* C. and R. Rev. N.A. Umbell. 112. 1888.

Perideridia californica (Torr.), n. comb.—*Chaerophyllum* (?) *californicum* Torr. Pacif. R.R. Rep. **4**:93. 1856; *Eulophus californicus* C. and R. *op. cit.* 114.

DODECATHEON JEFFREYI Van Houtte, Fl. des Serres **16**:99. 1865.—It seems doubtful if there are any indigenous plants in this country answering to the original description. Even the specimens from the Californian Sierras that we have seen do not have "hispidulous styles and a capsule valvate from the very apex." The description was drawn from European garden plants, supposedly grown from Californian seed, but this might easily have been an error. The plant that has long passed as *D. Jeffreyi* seems to be quite variable, and that has led to different forms of it receiving specific names, so that now its name and synonomy seems to be as follows:

DODECATHEON VIVIPARUM Greene, Erythea **3**:38. 1895; D. *tetrandum* Suks. ex Greene, *op. cit.* 40; *D. crenatum* Greene, Pitt. **2**:74. 1890, not *D. crenatum* Raf.; *D. dispar* A. Nels. BOT. GAZ. **52**:369. 1911.

FRASERA NITIDA Benth. var. **Cusickii** (Gray), n. comb.—*F. Cusickii* Gray, Proc. Am. Acad. **22**:310. 1887.—This is now represented in herbaria by a number of CUSICK'S collections and differs from the species only in the orbicular and concave scales between the filaments. These are nearly entire and surpass the ovary, as is not rare in the species. Both forms occur in Oregon, the variety seemingly confined to the northwestern part of the state.

Phacelia argentea, n. sp.—Differs from *P. magellanica* (Lam.) Coville, in the broad suborbicular or broadly oval densely sericeous leaves (2–4 cm. long, 2–3.5 cm. broad). Although evidently nearest related to *P. magellanica* as understood by BRAND in his discriminating monograph, *P. argentea* is of unique aspect, entirely different from any of the plants referable to this group. The stems and petioles are hispid or hirsute, but the leaf blades are clothed with an appressed (less so beneath) satiny pubescence.

The specimen is imperfect, but the plant is probably robust and tall. Even though only vegetative characters are available for discrimination, there is no evidence that these intergrade, so the plant is proposed as a new species.

Sandy seashore, Chetco, Oregon, June 1884, *Howell* no. 209 (type in Gray Herb.).

GILIA and COLLOMIA.—Although BRAND in his recent monograph of the Polemoniaceae maintains *Collomia* as a genus distinct from *Gilia*, it is surely no better marked than some other sections raised to generic rank by many American botanists. "Calyx not ruptured by the maturing capsule" is a good enough (and the only constant) sectional character, but scarcely to be considered generically in a family in which the more natural genera run hopelessly together technically. And when all the *Collomia* species are taken into account, they present no common aspect that might tempt one to treat them as a genus, a characteristic which some of the other sections possess. In accord with this view we are making two necessary transfers.

Gilia mazama (Coville), n. comb.—*Collomia mazama* Coville, Proc. Biol. Soc. Wash. **11**:35. 1897.

Gilia tenella (Gray), n. comb.—*Collomia tenella* Gray, Proc. Am. Acad. **8**:259. 1870.—The range given in the COULTER and NELSON *Manual* would be more nearly correct, if it read "Mountains of southern Idaho to Oregon and Utah."

GILIA ACHILLEIFOLIA Benth. var. **Chamissonis** (Greene), n. comb.—*G. Chamissonis* Greene, Erythea **3**:105. 1895; subsp. *Chamissonis* (Greene) Brand, Pflanzenreich 4, fam. 250. 111. 1907.—Mostly, if not entirely, replaces in the Northwest the typical form with permanently arachnoid-villous calyx. Both grow in California.

GILIA FLOCCOSA Gray var. **filifolia** (Nutt.), n. comb.—*G. filifolia* Nutt. Jour. Acad. Phil. **1**:156. 1848; *Navarettia filifolia* Brand, *op. cit.* 167; *G. virgata* Steud. var. *filifolia* Milliken, Rev. Col. Polem. 39. 1904.—Although *G. virgata* and *G. floccosa* admittedly merge, they are distinct enough in their typical development to warrant their separation, which is conducive to clearness and simplicity when one considers their respective variations. *G. Wilcoxii* A. Nels. BOT. GAZ. **34**:27. 1902 is *G. floccosa*. The foregoing variety is distinguished by its shorter, more salverform corolla, the narrow lobes much shorter than the tube.

POLEMONIELLA.—BRAND in his recent monograph of the Polemoniaceae reduces *Polemoniella* Heller, Muhl. **1**:57. 1904. This genus is undoubtedly as strong as the *Gilia* segregates he accepts. It not only has the technical characters indicated and the corolla shorter than the calyx, but these combine to give the plants an aspect that suggests *Nemophila* or *Ellisia*. In fact, BRAND marked a specimen (in this herbarium) of *Polemoniella, N. breviflora*. Besides *P. micrantha* (Benth.) Heller, the genus contains the following species, both South American.

Polemoniella Gayanum (Wedd.), n. comb.—*Gilia Gayanum* Wedd. Chlor. And. **2**:82. 1859; *P. Gayanum* (Wedd.) Brand, Pflanzenreich **4**:46. 1907.

Polemoniella antarcticum (Griseb.), n. comb.—*P. antarcticum* Griseb. in Goett. Abh. **6**:131. 1854.

HELIOTROPIUM CURASSAVICUM L. var. **xerophilum** (Ckll), n. comb.—*H. xerophilum* Ckll. BOT. GAZ. **33**:379. 1902; *H. spathulatum* Rydb. Bull. Torr. Bot. Club **30**:262. 1903.—COCKERELL has called attention (Proc. Biol. Soc. Wash. **26**:204. 1913) to the fact that his name for this large-flowered inland form antedates RYDBERG'S. He is wrong, however, in believing that it is the only form found in New Mexico and Chihuahua, there being collections from these localities that represent the species perfectly. Especially in California and the Southwest intermediates occur which prove the fallacy of trying to maintain the inland plant as a species. *H. oculatum* Heller, Muhl. **1**:58. 1904, judging from the author's specimens, is one of these intermediate states. In its best development, however, the variety is

strongly marked by its almost showy flowers and usually broader leaves.

Amsinckia Menziesii (Lehm.), n. comb.—*Echium Menziesii* Lehm. Pug. **2**:29. 1830; *A. intermedia* F. and M. Ind. Sem. Hort. Petrop. **2**:26. 1835.—PIPER in Contrib. Nat. Herb. **11**:480. 1906 cites under *A. intermedia*, "*Eutoca Menziesii*," etc., "not R. Br. 1823." However, LEHMANN did not publish the species as a *Eutoca* but as an *Echium*. Hence his name is five years earlier than that of FISCHER and MEYER'S, and there is no earlier *Menziesii* in the genus *Amsinckia*. This variable species should therefore bear the name *A. Menziesii* according to both the American and the international rules of botanical nomenclature. It is possible that some of the segregate species proposed rather recently are valid or at least worthy of varietal rank.

ALLOCARYA SCOULERI (H. and A.) Greene var. **hirta** (Greene), n. comb.—*A. hirta* Greene, Pitt. **1**:161. 1887.—Differs from the species in being more or less setosely hispid, the leaves ciliate with widely spreading hairs. It is represented in the Gray Herbarium by SUKSDORF'S no. 45, Klickitat County, Washington, May 26, 1881.

ALLOCARYA CUSICKII Greene var. **jucunda** (Piper), n. comb.—*A. jucunda* Piper, Bull. Torr. Bot. Club **29**:643. 1902.—In the original description the leaves are said to be glabrous above, but they vary in this respect as in the species. The shorter and relatively broader leaves, together with the more bristly hirsute pubescence, serve to distinguish the variety. The nutlets are essentially the same.

LAPPULA.—The following key and the accompanying notes are given in the hope of helping to clear up the confusion that has existed in regard to our annual species of *Lappula*. No one apparently has ever made a serious effort to determine to what plants the names in literature actually apply, and consequently this section of the genus has reached a nearly chaotic condition.

Nutlets not cupulate, the prickles distinct nearly or quite to the base
Prickles in two rows
Nutlets 2.5–3 mm. long, the granulations on the face minute and even
1. *L. echinata*

Nutlets 4–7 mm. long, the median tuberculations more prominent than the outer

Plant not bushy branched, ashy pubescent; nutlets 4–4.75 mm. long
2. *L. Fremontii*

Plant bushy branched; herbage green; nutlets 6–7 mm. long
3. *L. cenchrusoides*

Prickles in one row ..... 4. *L. Redowskii*, 4*a*, and 4*b*.

Nutlets, at least in part, cupulate

Cup shallow, the prickles united toward the base and forming a spreading flange, scarcely or not at all inflated; nutlets all alike

Pubescence rather soft, little papillose; stems branched above
5. *L. cupulata*

Pubescence harsher, more papillose; stems branched from the base
5*a*. var. *foliosa*

Cup deep, the inflated margin more or less involute; nutlets frequently dissimilar

Stems branched above; pubescence soft; nutlets dissimilar, strongly tuberculate on sides and face ..... 6. *L. texana*

Stems branched and floriferous from the base

Nutlets dissimilar ..... 6*a*. var. *heterosperma*

Nutlets similar

Faces and sides tuberculate ..... 6*b*. var. *homosperma*

Faces and sides smooth ..... 6*c*. var. *coronata*

1. LAPPULA ECHINATA Gilib. Fl. Lith. **1**:25. 1781: *L. Lappula* (L.) Karst. Deutsch. Fl. 979. 1880–1883.—This widely naturalized species has the prickles of the nutlets quite distinct to the base and in two very evident marginal rows.

2. LAPPULA FREMONTII (Torr.) Greene, Pitt. **4**:96. 1899.—*L. erecta* A. Nels. Bull. Torr. Bot. Club **27**:268. 1900 as to specimens cited and description in large part.—This was described as having the prickles of the nutlets in a single row. Since they are in two irregular rows in authentic specimens this must have been an oversight. Part, at least, of the original collection of *L. Fremontii* is deposited at the Gray Herbarium, and *L. erecta* is clearly a synonym. The species is a good one. It is distinguished from *L. Redowskii* by the double row of prickles and from *L. echinata* (its nearest relative) by the distinctly larger nutlets, the more irregular distribution of the prickles, and the tendency of the median tuberculations to become more prominent, differences well noted by TORREY in his original diagnosis (Pacif. R.R. Rep. **12**:46. 1860).

Specimens examined: ASSINIBOIA: Crane Lake, June 15, 1894, *John Macoun* (5807); WYOMING: Fort Steele, Carbon County, June 16, 1900, *Aven Nelson* (7257); Chug Creek, June 29, 1900, *Aven Nelson* (7302); Laramie, Albany County, June 10, 1900, *Aven Nelson* (7269); UTAH: Carter Dugway, Uintah Mountains, July 19, 1902, *Leslie N. Goodding* (1410).

3. LAPPULA CENCHRUSOIDES A. Nels. Bull. Torr. Bot. Club **26**:243. 1899.—GREENE (*loc. cit*) states that this is a synonym of *L. Fremontii*. It is much nearer a *Lappula* of Asia. *L. cenchrusoides* is low, bushy branched, with the pubescence so scanty that the herbage has a clear green hue, giving an aspect that is entirely different from that of the strict gray-pubescent *L. Fremontii*. The fruits, too, are much larger and are not mature until late August or September, long after *L. Fremontii* has dried away. The only specimens we have seen are from sandy canyons in the Laramie Hills. These are identical with specimens of the Asian *L. semiglabra* (Ledeb.) Gurke, except that the prickles are in two rows.

4*a*. LAPPULA REDOWSKII (Hornem.) Greene var. OCCIDENTALIS (Wats.) Rydb.—This variety has always been supposed to be confined to North America. It is, however, impossible to distinguish the Siberian specimens referred to the species by LEDEBOUR, DECANDOLLE, and others. HOOKER (Fl. Brit. India **4**:163) gives what seems to be the correct range for the species. HORNEMANN (Hort. Hafn. **1**:174) stated that the original was sent from Moscow and purported to have been collected in "Imperio Ruthenico," probably somewhere in Southwestern Russia. The supposed differences in branching break down completely, but the repeatedly described fruiting differences are well marked.

There is another interesting variation of the species that has been collected in this country on ballast. This is *L. patula* (Lehm.) Aschers. WATSON (Bot. King Exped. 246. 1871) gives a somewhat exaggerated figure but a good presentation of its diagnostic characters. He writes "differs from *E. Redowskii* only in the tuberculations upon the fruit, which are few in number and arranged regularly in longitudinal rows upon the back and upon the outer edge of the sides." Some of the specimens are separated from *L. Redowskii* only with difficulty. HOOKER as long ago as 1885 (Fl. Brit. India **4**:163), in a note after *E. Redowskii*, wrote "perhaps

E. patulum Lehm. is not specifically distinct." Altogether, it seems well to treat it as a variety. Like the species, it is a native of Southern Asia and Southeastern Europe.

4*b*. LAPPULA REDOWSKII (Hornem.) Greene var. **patula** (Lehm.), n. comb.—*Echinospermum patulum* Lehm. Asperif. **1**:124. 1818.

Specimens examined: PENNSYLVANIA: Philadelphia, May 1877, *Isaac C. Martindale;* Greenwich Point, June 23, 1877, *Parker;* OREGON: Linnton, near Portland, July 12, 1912, *W. N. Suksdorf* (1930); AUSTRO-HUNGARY: between Paks and Komlod, *Haynald* (3707); ALGERIA: Hedna, 1865 (possibly introduced); ELISABETHPOL (in Caucasia), June 1834, *Hohenacker.*

5. LAPPULA CUPULATA (Gray) Rydb. Bull. Torr. Bot. Club **28**:31. 1901.—*Echinospermum Redowskii* (Hornem.) Lehm. var *cupulatum* Gray, Bot. Calif. **1**:530. 1876; *L. columbiana* A. Nels. BOT. GAZ. **34**:28. 1902.—GREENE (Pitt. **4**:94. 1899), referring to var. *cupulata*, wrote "that was made to include a number of easily definable species, and there is no determining to what one of the segregate species the name should be applied rather than to another." The first part of this statement is undoubtedly correct; but fortunately, as PIPER (Contrib. Nat. Herb. **11**:475. 1906) indicated, the proper application of the name *cupulata* is perfectly clear. The original specimen cited by WATSON (*op. cit.* 247), no. 862, Trinity Mountains, Nevada, May 1865, and later indicated by GRAY (*loc. cit.*), is deposited in the Gray Herbarium. This plant is well described by AVEN NELSON (*loc. cit.*), who followed RYDBERG'S conception of *L. cupulata* (*loc. cit.*). The latter's remarks no doubt apply to the Rocky Mountain variety of *L. texana* (Scheele) Britton, a very different plant. *L. cupulata* (Gray) Rydb., in addition to its strong fruiting characters, has a very distinct range, as is shown by the following typical specimens.

IDAHO: Snake River Plains, 1893, *Edward Palmer* (19, 115, and 78); sandy soil, valley of Clearwater River, Nez Perces County, April 24, 1892, *Sandberg, Macdougal,* and *Heller* (17); OREGON: Pine Creek, Crook County, June 12, 1894, *J. B. Leiberg* (213); eastern Oregon, 1898, *William C. Cusick* (1945); WASHINGTON: Almota, May 27, 1893, *C. V. Piper* (1703).

On the dry plains of southern Idaho and Wyoming a variation of the above occurs that is bushy branched, the branches floriferous nearly to the base, a variation common in this genus and always

intergrading more or less with the typical form. Extremes in habit so striking, however, are often well worthy varietal rank. Such is the case with

5a. LAPPULA CUPULATA (Gray) Rydb. var. **foliosa** (A. Nels.), n. comb.—*L. foliosa* A. Nels. in COULTER and NELSON Rocky Mountain Botany 413. 1909.

Specimens examined: IDAHO: dry stony plains, Castleford, Twin Falls County, June 26, 1912, *Nelson* and *Macbride* (1709); Snake River Plains, 1893, *Edward Palmer* (280); dry river bank, St. Anthony, July 5, 1901, *Merrill* and *Wilcox* (839); WYOMING: waste ground, Bench, Uinta County, June 25, 1902, *Leslie N. Goodding* (1188); gravelly slopes, Kemmerer, Uinta County, June 1, 1907, *Aven Nelson* (9015).

6. LAPPULA TEXANA (Scheele) Britton Mem. Torr. Bot. Club **5**:27. 1894.—*L. collina* Greene, Pitt. **4**:96. 1899.—It seems strange that this strong species has been misunderstood for so long. Ever since GRAY reduced it to his totally different var. *cupulata*, there is scarcely an annual *Lappula* that at some time or other has not masqueraded under the name. SMALL'S Fl. S.E.U.S. 997. 1913 contains the most nearly correct description that has come to notice. As indicated in the key, the species and its variations are separable at a glance from *L. cupulata* by the different fruit. The dissimilarity of nutlets is a striking character that is absolutely valid for the typical form. The following specimens (many from San Antonio, the type locality) indicate a range far removed from *L. cupulata*. Where the species meet in one form or another in the central Rocky Mountains, the fruit characters remain just as pronounced.

Specimens examined: TEXAS: San Antonio, April 17, 1894, *A. A. Heller* (1585); gravelly plain, San Antonio, April 1853, *George Thurber;* San Antonio, *G. Jermy* (225); San Antonio, 1841, *F. Lindheimer* (477); light sandy soils, Brown County, April, *J. Reverchon* (2117*a*); Comaniche, May 10, 1900, *H. Eggert;* Abilene, May 20, 1902, *S. M. Tracy* (7833); El Paso, March 1851, *George Thurber* (153); NEW MEXICO: 1851, *C. Wright* (1573).

Northward the plant gradually assumes a habit entirely analogous to *L. cupulata* (Gray) Rydb. var. *foliosa* (A. Nels.) Nels. and Macbr., which, becoming extreme in Colorado and Wyoming, may be known as

6*a*. LAPPULA TEXANA (Scheele) Britton var. **heterosperma** (Greene), n. comb.—*L. heterosperma* Greene, Pitt. **4**:94. 1899; *L. desertorum* Greene, *op. cit.* 95; *L. cucullata* A. Nels. BOT. GAZ. **34**:29. 1902, at least as to specimens cited.—*L. cucullata* was described as having similar nutlets, but authentic specimens have exactly the nutlets of *L. heterosperma*.

Specimens examined: WYOMING: Sandy plains, Fort Steele, Carbon County, June 16, 1900, *Aven Nelson* (7250); sandy canyon, Birds Eye, Fremont County, June 22, 1910, *Aven Nelson* (9407); COLORADO: dry hills, Paradox, Montrose County, June 13, 1912, *E. P. Walker* (80); 1864, *Parry* (3).

6*b*. LAPPULA TEXANA (Scheele) Britton var. **homosperma** (A. Nels.), n. comb.—*L. heterosperma* Greene var. *homosperma* A. Nels. BOT. GAZ. **34**:29. 1902.

Specimens examined: ASSINIBOIA: Medicine Hat, July 5, 1894, *John Macoun* (5806); MONTANA: Gallatin City, June 20, 1883, *F. Lamson Scribner* (172); COLORADO: New Windsor, Weld County, June 4, 1901, *George E. Osterhout* (2388); Mesa County, May and June, 1893, *H. C. Long*.

6*c*. LAPPULA TEXANA (Scheele) Britton var. **coronata** (Greene), n. comb.—*L. coronata* Greene, Pitt. **4**:94. 1899.—This variety seems to be an extreme desert form of the south, almost too close to the preceding. It is a smaller plant, however, the nutlet margins being inordinately developed and the faces and sides smooth or merely somewhat papillose. A variation of *L. Redowskii* occurs in Europe which is not unlike this, the nutlets exhibiting the same tendency to smoothness.

Specimens examined: ARIZONA: dry plains near Camp Lovell, April 16, 1881, *C. G. Pringle* (362); dry hills, Santa Cruz, April, 1884, *W. F. Parish*, (164).

LAPPULA ARIDA Piper var. **Cusickii** (Piper), n. comb.—*L. Cusickii* Piper, Bull. Torr. Bot. Club **29**:542. 1902.—Like the species except in the smaller and blue flowers. The forms are entirely similar in aspect and the nutlets are the same. Although the author suggested the possibility that future collections might prove *L. Cusickii* a synonym of *L. arida*, the size and color of the flowers of the former seem to remain constant, and therefore it may well be left as a variety.

LAPPULA SUBDECUMBENS (Parry) A. Nels. in COULTER and NELSON Rocky Mountain Botany 412. 1909.—PIPER, in his excellent revision of the western perennial species of *Lappula* (Bull. Torr. Bot. Club **29**:539. 1902), wrote "*Echinospermum subdecumbens* Parry is probably a synonym of *L. diffusa*." Others have shared this view, so a few remarks calling attention to this evident error may not seem inappropriate.

LAPPULA DIFFUSA (as described) has glabrous or merely papillate corolla appendages. The material from the Wasatch Mountains, Utah, which represents the plant PARRY was writing about in Proc. Davenport Acad. **1**:148. 1876, has softly pilose appendages. Moreover, where the species meet in Idaho they are consistently distinct as to color, *L. subdecumbens* being white or merely marked with blue, thus agreeing with material from the type region. These are two of the characters of which PIPER rightly makes so much. They are strengthened in this case by an evident difference in habitat. *L. subdecumbens*, PARRY tells us (*loc. cit.*), is "quite common in gravelly débris at the outlet of ravines," and GARRETT in his *Spring flora of the Wasatch region* notes that it grows on "dry plains and hillsides." *L. diffusa*, on the other hand, is a species of streamlands and woods or thickets. In southern Idaho and adjacent Nevada it is not infrequent to find the species growing within a few yards of each other, the one on the dryer, higher, and usually rocky places, the other on the moister and richer flats or slopes. The ranges of the two are at present not well enough known to be significant, but in all probability will later prove interesting. *L. caerulescens* Rydb., with long-hirsute appendages, is no doubt rightly treated by GARRETT as a variety of the Utah plant. It extends much farther north than the typical form.

Cryptantha muricata (Hook. and Arn.), n. comb.—*Myosotis muricata* Hook. and Arn. Bot. Beechy 369. 1840; *C. muriculata* (A.DC.) Greene, Pitt. **1**:113. 1887.—DECANDOLLE, treating this plant as an *Eritrichium* (Prodr. **10**:132. 1846), discarded HOOKER and ARNOTT'S name because of the earlier and valid *E. muricatum* (R. and P.) DC. The latter is now known to belong to the genus *Allocarya*. Accordingly, the earliest name, not

being preoccupied in the genus *Cryptantha*, must replace *muriculata* DC.

LEHMAN'S genus has been commonly spelled *Cryptanthe* ever since GREENE resurrected it. The first valid publication, however, seems to have been by FISCHER and MEYER in Sem. Hort. Petrop. 35. 1836, and there at least the name is *Cryptantha*.

CRYPTANTHA TORREYANA (Gray) Greene var. **grandiflora** (Rydb.), n. comb.—*C. grandiflora* Rydb. Bull. Torr. Bot. Club **36**:679. 1909.—Because of the conspicuous corolla (5–6 mm. wide) this may well deserve varietal rank. The leaves are often, though not always, broader than those of the species.

Oreocarya salmonensis, n. sp.—Pallid throughout; duration unknown: stems solitary or few, apparently not tufted, simple, 1. 5–2 dm. high, distinctly angled, very leafy, white-hispid, and finely strigose with reflexed hairs: leaves (basal unknown) large for the genus, 3–8 cm. long, scarcely reduced below the inflorescence, oblanceolate or broadly spatulate, obtuse, the lower strongly 1-nerved, hispid-ciliate, petiolar portion about as long as the sparsely pustulate-hispid and finely and intricately pubescent blade: inflorescence thyrsoid-glomerate, dense, even in fruit: calyx lobes pubescent like the leaves, but not pustulate, linear-lanceolate, 5–7 mm. long in fruit: corolla white, the tube shorter than the calyx: anthers oblong: nutlets fully 3 mm. long, long-ovate, obtuse, acutely margined, smooth and shining, gray with a lighter indistinct keel on the back; scar linear, nearly as long as the nutlet, forked at the very base.

Unique among the short corolla species of the Northwest, being the only one with smooth nutlets. Equally distinct in leaf and inflorescence from the *O. multicaulis* group of the South and from *O. leucophea*. The type is by *Charles L. Kirkley*, "prairies, in loose soil," Salmon, Idaho, June 1896.

OREOCARYA CILIO-HIRSUTA Nels. and Macbr. BOT. GAZ. **55**: 378. 1913 is *O. spiculifera* Piper, Contrib. Nat. Herb. **11**:481. 1906. The species is very well marked by its usually numerous stems and striking pubescence.

Nicotiana Torreyana, n. n.—*N. attenuata* Torr. in Wats. Bot. King Exped. 276. 1871; not *N. attenuata* Steudel, Nom. ed. 1. 554. 1821.

PEDICULARIS CONTORTA Benth. var. **ctenophora** (Rydb.), n. comb.—*P. ctenophora* Rydb. Bull. Torr. Bot. Club **24**:293. 1897.—Distinguished from the species by the more or less villous-ciliate calyx base. The variety has a purplish corolla, that of the species usually being yellow. Both forms occur in Montana and Yellowstone Park, but the variety seems to be confined to the eastern part of the plants' range.

Besides the type, the following collections may be noted: MONTANA: near snow, July 17, 1880, *Watson* (326); YELLOWSTONE PARK: 1884, *R. S. Williams* (809); WYOMING: Bighorn Mountains, July 19, 1900, *J. G. Jack*.

MIMULUS LANGSDORFII Don var. **microphyllus** (Benth.), n. comb.—*M. microphyllus* Benth. DC. Prodr. **10**:371. 1846; *M. luteus* L. var. *depauperatus* Gray.—As pointed out by GRAY in Syn. Fl. 448. 1886, this often grows with the typical form. Such is not always the case, however; and when it is found by itself its slender and few-flowered stems, and small leaves and flowers make it hard to consider it as identical with the well developed state.

CASTILLEJA PILOSA (Wats.) Rydb. var. **inverta** (Nels. and Macbr.), n. comb.—*C. fasciculata* A. Nels. var. *inverta* Nels. and Macbr. BOT. GAZ. **55**:381. 1913.—Although bearing a striking resemblance to the species to which we first referred it, the plant is rather a variation of *C. pilosa*, since it has the unequally cleft calyx of that species. The short corolla and the short, fine pubescence seem to make it the connecting link between two groups in this genus.

CASTILLEJA CONFUSA Greene, Pitt. **4**:1. 1899.—An examination of a large amount of material in this group (the *miniata* group), both in herbaria and in the field, has convinced us that some of the characters relied upon to maintain proposed species are both inconstant and inconsequential. For instance, *C. confusa*, when rightly interpreted, should not be confined to plants that have the two primary calyx lobes so deeply cleft that the calyx appears 4-lobed, for this character exists in all degrees, but should include all those plants of its alliance with galea only one-half to one-third as long as the tube. The latter is a fairly constant character and must be the chief if not the only means, often, of separating *C. confusa* from *C. miniata*, in which it was at one time included.

The galea of the latter plant is nearly or quite as long as the tube. Measured by this yardstick the group divides into two species which are more or less distinct in habit and aspect. Both present interesting and analogous variations in pubescence; one, *C. rexifolia* var. *pubens* Nels. and Macbr., with this interpretation of *C. confusa* must become

CASTILLEJA CONFUSA Greene var. **pubens** (Nels. and Macbr.), n. comb.—C. *rexifolia* Rydb. var. *pubens* Nels. and Macbr. BOT. GAZ. **55**:380. 1913.

CASTILLEJA MINIATA Dougl. var. **crispula** (Piper), n. comb.—*C. crispula* Piper, Contrib. Nat. Herb. **11**:516. 1906.—The bracts, at least the uppermost, are few-toothed near the apex. The species varies somewhat in the dissection of the bracts.

CASTILLEJA ANGUSTIFOLIA (Nutt.) G. Don var. **subcinerea** (Rydb.), n. comb.—*C. subcinerea* Rydb. Bull. Torr. Bot. Club **40**:484. 1913.—Since FERNALD published his discriminating analysis of this group (Eryth. **6**:41–51), several additional species have been described, among them *C. subcinerea* Rydberg. This form is of particular interest as it in some degree connects *C. angustifolia* and its varieties with *C. Bennittii* Nels. and Macbr. of southwestern Idaho. The latter is very distinct, however, by reason of its subequal corolla and calyx and the color of its bracts (old rose). The eastern Idaho plant (*C. subcinerea*), although simulating *C. Bennittii* in pubescence, has the well-exserted corolla and relatively long calyx (2–3 cm.) of the old species. It would seem conducive to clearness and more natural, therefore, to treat it as another variety of *C. angustifolia*, regarding its pubescence as its most marked characteristic.

CORDYLANTHUS BICOLOR A. Nels. BOT. GAZ. **54**:416. 1912.—RYDBERG (*loc. cit*) states that this species "is evidently the same as *Adenostegia ciliosa* Rydb." The latter, however, is the same as *C. ramosus* Nutt., which has 4 stamens and 2-celled anthers. *C. bicolor* is distinguished from *C. capitata*, its nearest relative, which has 2 stamens and 1-celled anthers, by its viscid-glandulosity and the presence of a rudimentary anther cell.

Ricinophyllum horridum (Sm.), n. comb.—*Panax horridum* Sm. Rees Cycl. **26**: no. 10. 1812; *R. americanum* Pall. ex Ledeb.

Fl. Ross. **2**:375. 1844; *Fatsia* and *Echinopanax* Dcne. and Planch. Rev. Hort. **4**:105. 1854.—This widely distributed and conspicuous plant ought to bear its acknowledged earlier designation.

Gnaphalium Ivesii, n. n.—*G. decurrens* Ives Am. Jour. Sci. **1**:380. 1819, not L. Syst. ed. 10. 1211. 1758.

Gnaphalium Grayi, n. n.—*G. strictum* Gray, Pacif. R.R. Rep. **4**:110. 1858, not Moench, Meth. Pl. Hort. Bot. et Agric. 576. 1794; nor Roxb. Hort. Bengal. 61. 1814.

Gaillardia crassifolia, n. sp.—Apparently perennial from a thickened semi-fleshy root, pale green, sparsely pubescent with fine, short, jointed hairs, the pubescence extending to all parts of the head: stems few to several from the crown, branching from near the base and upward, striate, 3–5 dm. high, the upper third pedunculate: root leaves (wanting) probably early deciduous; the lower stem leaves narrowly oblanceolate, 3–8 cm. long, on slender-margined petioles often as long as the blade; the upper narrower, becoming linear and nearly sessile; heads medium; the disk 15–20 mm. broad, corollas purplish above; rays yellow, rather short (15 mm. or less), cleft into narrowly oblong lobes: achenes short, densely pubescent all over: pappus longer than the achene, the weak awn longer than the scarious portion.

M. E. Jones no. 5177, La Verken, Utah, May 7, 1894, is the type. Another specimen by *Jones* from Green River, Utah, June 21, 1889, is doubtfully referred to the proposed species.

SENECIO CANUS Hook. var. **celsus** S. S. Sharp, n. var.—More densely tomentose, usually with a tuft of white wool at the base: stems stouter, single, or somewhat tufted (not tufted as in the species), 3.5–5 dm. high: basal leaves oval, repand, dentate, or sinuately dentate, obtuse, 2–3 cm. broad, larger than in the species; upper leaves oblong-lanceolate, sinuately dentate, mostly sessile: heads 12–20, in a subumbellate cyme, 15 mm. broad, on peduncles 3–10 cm. long; bracts sometimes dark-tipped, silky-hairy or often tomentose at base; rays about 10.

The type was found on grassy banks in Little Goose Canyon, 15 miles south of Sheridan, Wyoming, at an elevation of about 5000 feet, no. 362, *Seymour S. Sharp,* June 22, 1913. No. 2332, *Aven Nelson,* from exactly the

same locality July 15, 1896, is also typical. In size and general aspect, this variety seems to differ considerably from typical forms of *S. canus*.

Hieracium cineritium, n. n.—*H. cinereum* Howell, Fl. N.W. Am. 396. 1901, not Doell, Rhein Fl. 524. 1843; *et al.*

MICROSERIS NUTANS (Geyer) Gray var. **major** (Gray), n. var. —*M. major* (Gray) Sch. Bip. 1866; see *Kew Index* and GRAY *Syn. Fl.*—Except for the large heads this plant has no constant character different from the typical form.

MICROSERIS NUTANS (Geyer) Gray var. **macrolepis** (Rydb.), n. comb.—*Ptilocalais macrolepis* Rydb. Bull. Torr. Bot. Club 38:11. 1911.—This is exactly like the variety *major* (Gray) Nels. and Macbr. except for the lanceolate-attenuate and elongate pappus scales. Thus intermediate between the species and the latter variety, which belongs to Oregon and Idaho, it seems best to consider it a geographical variant.

The following specimens may be noted in addition to those cited by RYDBERG: UTAH, Salt Lake City, May 1869, *Sereno Watson* 696 (referred by GRAY Syn. Fl., to *M. major*); Fort Douglas, May 25, 1908, *Mrs. Joseph Clemens;* Emmigration Canyon, Salt Lake County, June 14, 1913, *A. O. Garrett* (2726*b*).

ROCKY MOUNTAIN HERBARIUM
UNIVERSITY OF WYOMING, LARAMIE

A MEXICAN AYTONIA

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY 211

ANNA M. STARR

(WITH PLATES I–IV AND FOUR FIGURES)

To this genus ENGLER and PRANTL refer six names, among which *Aytonia* Forst and *Plagiochasma* L. are most familiar in botanical literature. LEITGEB (14) made a study of *Plagiochasma cordatum*, *P. intermedium*, *P. crenulatum* (Gottsche), *P. appendiculatum*, and *P. Aytonia*. He gives an account of the appearance, the position, and the formation of the antheridial and archegonial receptacles, describing the order of the appearance of the archegonia and the origin of the archegonial cavity and of the involucre. He describes also the protective scales about the receptacles and their origin from a single row of cells, and accounts for the stalk of the receptacle as simply a dorsal outgrowth of the thallus. He concludes with an account of the structure of the sporogonium and its dehiscence.

The material for this investigation was collected in Mexico in 1908 by Dr. W. J. G. LAND and the late Dr. CHARLES R. BARNES. Most of it came from the rocky sides of the deep canyon of the Rio Santiago in the state of Jalisco near Guadalajara, the rest from Carrizal in the state of Vera Cruz. The species cannot be determined definitely. Of the four Mexican forms described by GOTTSCHE, it resembles most closely his *Plagiochasma crenulatum*, but differs in that the ventral scales reach the margin of the thallus. This Mexican form presents some variations in external appearance, and an examination of structure offers some details not covered by LEITGEB, so that it has seemed worth while to give a description of the external appearance, an account of the internal structure of the thallus and of the formation of rhizoids, a complete description of the development of the air cavities of the archegonial receptacle, and an addition to the history of development following fertilization.

Vegetative body

The thallus (fig. 1) is dorsiventral, dichotomously lobed and branched, with no groove on the dorsal side, but on the ventral side (fig. 2) a thickened median region, covered thickly with scales and rhizoids. The upper surface is green, showing purple at the edges; the ventral is light along the central region, with broad purple wings; the scales are in two rows, extending laterally from the median line, arranged alternately; they are attached along the posterior edge, lapping over those in front, and are shaped like the half of a crescent and have one or two appendages, the scales being purple and the appendages hyaline (fig. 3). Two appendages seem not to have been reported before.

The first rhizoids appear behind the first three or four pairs of scales and then occur in great abundance between the scales. They are of two kinds, pegged and smooth, the pegged appearing in bunches. They are deformed at the ends (fig. 4), but are not branched. The smooth rhizoids vary greatly in size, and frequently within the larger, smaller ones are produced (fig. 5); whether this occurs only when the larger are injured could not be determined, as most of the rhizoids were broken in collecting. The exterior rhizoids, having heavy walls, appear much older than those inside. This phenomenon is not uncommon in liverworts, often appearing in *Marchantia*, in which pegged rhizoids sometimes occur within plain ones. DIXON (**9**) also reports rhizoids within rhizoids in *Lunularia cruciata*, *Dumortiera hirsuta*, *Conocephalus conicus*, *Anthoceros punctatus*, and *Marchantia polymorpha*. WEINERT (**17**), in a study of *Marchantia* and *Conocephalus*, says "lost rhizoids are not regenerated, but other epidermal cells grow out into new rhizoids," which is plainly the case here. A new cell or several new cells just above the layer of old rhizoids push down into the cavity of the old rhizoid.

Structure

The thallus shows the usual differentiation into thin wings of spongy tissue and a thick median region composed of close colorless tissue below and spongy chlorophyllose tissue above, the latter

often occupying almost all of the thallus. The cavities have no regular chlorophyllose filaments, although single cells frequently project into them (figs. 11 and 16). In these respects *Aytonia* differs markedly from *Marchantia*, *Fegatella*, and *Targionia*.

The close tissue of the thallus is generally infested with intracellular fungi (fig. 6), filamentous, non-septate, not contracted in passing through the walls, branching irregularly, and forming sporelike bodies occasionally as vesicles within a swollen part of the main filament or in short branches. One naturally questions the origin of the fungi and the relation existing between them and the liverworts. CAVERS (**6**) reports fungi in many liverworts, and says they are nearly always related to the soil, always occurring with humus; then he finds them traversing the rhizoids and extending into the lowest layers of the compact tissue; he thinks the fungus-bearing plants are larger and thicker than others. GOLENKIN (**12**) reports "endotropic mycorhiza" in five liverworts, and thinks they are "for storing water." NĚMEC (**15**) implies the entrance of the fungi through the rhizoids, and describes a pseudoparenchyma formed by them on the wall of the cells of the thallus. GARJEANNE (**10**) also finds them entering through the rhizoids and thinks the relation may be accidental, a case of true parasitism, or a case of true symbiosis. Miss CLAPP (**7**) is the only one who has traced the history of the infection back to the very early stages of the sporeling. She finds fungi in as young a plant as the 4-celled stage, and states that development is hastened by the presence of the fungus. According to her, infection of rhizoids occurs from the thallus. I am inclined to think that both methods of infection of the rhizoids may happen; that the plant may become infected at any stage of development; when considerable mycelium has developed, the hyphae may grow out through the rhizoids; and when the infection occurs late the hyphae may enter through the rhizoids. In my material the fungi are only in the older parts of the thallus, and when they occur in rhizoids seem to be always growing toward the thallus (fig. 7); but in living material of *Marchantia* and *Fegatella* I have found the hyphae passing out through the rhizoids. I find no "pseudoparenchyma" or balling up of hyphae, described by NĚMEC.

Cells secreting mucilage and resinous oils appear singly in thallus, receptacles, and scales; sometimes there is a layer of enlarged mucilage cells on the lower surface. Mucilage hairs are common about the receptacles and in the antheridial cavities. The middle lamella of the radial walls of the epidermal cells shows a tendency to become mucilaginous. Pitted cells occur in both the compact and loose tissue; they are not elongated more than other cells (fig. 8).

Development

Growth takes place by divisions of a wedge-shaped apical cell (fig. 9), as described by LEITGEB. From the lower segments scales are formed almost immediately, but rhizoids not until later. The epidermal cell giving rise to a rhizoid is often larger than the resulting rhizoid, forming a bulbous base. Division in the lower part of the thallus is more rapid than in the upper, indicated by the pulling backward of the bottoms of the air cavities. LEITGEB's theory of the origin of air cavities, as due to depressions in the surface and the upgrowth of adjacent parts, was combated by BARNES and LAND (1) and by PETSCH (16), but was upheld by Miss BLACK (2) in regard to *Riccia Frostii*. My material leaves no doubt as to their schizogenous origin (fig. 10). LEITGEB thought the spaces in *Plagiochasma* became partitioned by the outgrowth of cell plates. CAMPBELL (4) also says that the original air chambers become divided by the development of partial diaphragms into secondary chambers. The cavities at first are always deep and narrow, as noted by BARNES and LAND, but they soon become wide, irregular chambers by the stretching and tearing of tissues between neighboring chambers, as shown by the irregularity of the resulting surfaces and by torn cells, the tearing being due to the differences in tension between the upper and lower parts of the thallus. This leaves projecting plates of cells, appearing as filaments in section, which LEITGEB and CAMPBELL interpreted as new growth dividing the original chambers. Perhaps these plates add to their length by further growth. In fig. 11 projecting filaments *a* and *b* are attached in the next section.

The receptacles are formed in a direct line behind the growing point. LEITGEB noted that they are not complete branches of

the thallus, but only dorsal outgrowths. As the apical cell goes on dividing, the receptacles come to stand on the back of the thallus in a row along the median line, the antheridial appearing first, the archegonial later. Occasionally antheridial receptacles are again formed after the archegonial. Several rows of scales and mucilage hairs, dorsal outgrowths also, surround both receptacles (fig. 12).

The first indication of a receptacle is a slight elevation caused by a rapid division of the cells. My material has no early stages of the antheridial receptacle; when mature it is without a stalk and does not rise much above the surface of the thallus (fig. 12); it is cordate in shape, with the notch toward the growing point (fig. 1). The surface is markedly papillate, caused by the upward growth of tissue about the antheridia, which agrees with LEITGEB'S description. The deep cavities in which the antheridia stand, open to the surface by simple air pores, resembling those of the thallus except that at times there is greater projection (fig. 13). The archegonial receptacle appears in an early stage (fig. 14) as a small, bulbous outgrowth of compact, rapidly dividing cells in which are numerous chloroplasts containing starch. The cells of the under part divide radially as well as tangentially, with such regularity that a row of cells can be followed for some distance, dividing into two rows, and these two later dividing again. In the lower portion the divisions are tangential only, but the cells increase both in length and in numbers. The lower part therefore forms the stalk, while the upper part continues bulbous. The cells of the thallus below the receptacle remain compact, while those on each side form porous tissue, growing rapidly and arching up around, so that the receptacle stands in a slight depression (fig. 12) until after the archegonia are mature. Fertilization probably takes place very easily. Later the stalk elongates and lifts the receptacle above the surface; it may attain the length of 3 or 4 mm.

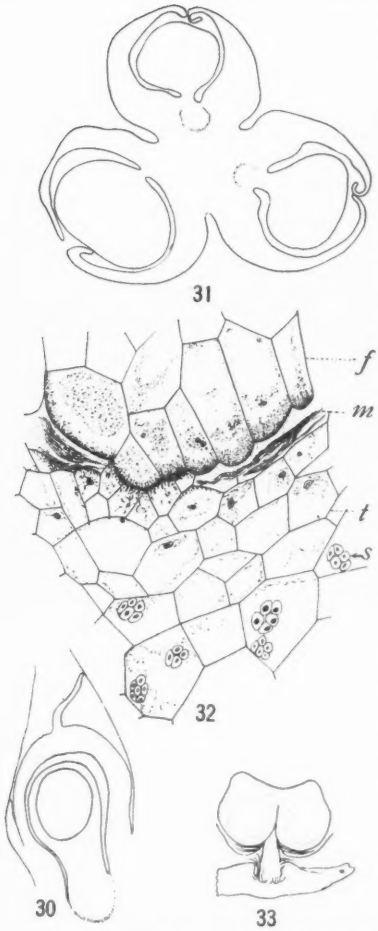
Air cavities appear early in the developing receptacle, starting about the same time as the archegonia, the origin being like that of the cavities of the thallus. The split occurs first at the juncture of epidermal and hypodermal cells (fig. 10), between cells of different segments of the apical cell, cells derived from the same segment

remaining attached for a longer time. The split may extend almost immediately to the surface (fig. 15) or be delayed until the formation of the pore (fig. 16). The structure of the pore is more elaborate than in cavities of the thallus, as noted by CAMPBELL (**3**) in archegonial receptacles in general. The cells destined to form the margin become evident by an increase in size (fig. 15); segments are cut off from the inner side, generally by oblique walls (fig. 17); more divisions occur until 3–5 rows of cells form a ring extending down into the enlarging cavity (fig. 18); then segments are cut off from the outer part of the cells of the margin, walls being again oblique, followed by another division, so that a projecting ring of cells three layers thick is formed (fig. 19). The cells of the last row shrink and become highly cutinized, giving a beaklike effect in section (fig. 20), as noted by DEUTSCH (**8**) in *Targionia*. I find no such thickening of the walls as LEITGEB shows in surface view, but only such an effect as appears in fig. 21, taken from the older part of the thallus. Of course my material may have grown under conditions entirely different from his. With the increase in size of the cavity the pore spreads and becomes a barrel-like opening. The development is not complete until fertilization has taken place and the receptacle has increased greatly in size.

Sex organs

The development of the antheridium is probably such as is general in the Marchantiaceae, but my material has no early stages. Occasionally the antheridium has a long stalk; less frequently the upper end is beaked; but the usual form is short-stalked and conical. About the antheridium are glandular hairs, and among the cells forming the wall of the pit are mucilage cells, the secretions from which probably assist the dispersal of the sperms. The antheridia are produced in acropetal succession, so that the younger are toward the apex (fig. 12).

The archegonia are reported by CAMPBELL (**5**) to be 3 or 4 in number, the one to the rear developing first, the lateral ones next, and the one in front last. My material confirms the statement in general, but 5 archegonia may occur. They begin development near the top of the receptacle (fig. 14), but are carried under



FIGS. 30–33.—Fig. 30, vertical section of a young sporogonium within the calyptra, ×132; fig. 31, transverse section of an archegonial receptacle, cutting obliquely through three sporogonia within their involucres which show the vertical opening; fig. 32, section through the region of contact of foot and thallus (*f*, foot; *t*, thallus; *m*, mucilaginous remains; *s*, starch), ×667; fig. 33, sketch of archegonial receptacle indicating the position of the sporogonia.

by the rapid growth of the tissue above (fig. 12). The stages of development that appear indicate the sequence usually given. In 1897 GAYET (11) claimed that he had demonstrated in *Marchantia*, *Preissia*, and other Hepaticae, that division in the cover cell by intersecting quadrant walls does not take place until a late period, and that before it occurs repeated segments are cut off its lower face, which add to the length of the neck. Figs. 24, 26, and 27 leave no room for doubt that in *Aytonia* a quadrant division occurs early in the cover cell, and that the neck lengthens by divisions lower down. The neck cells divide simultaneously until 8 cells are formed (fig. 27), showing greater regularity than is commonly reported. The egg has a large nucleus but no "receptive spot"; it fills the cavity of the venter up to the time that fertilization is to take place; then the cells forming the wall of the venter divide rapidly, parallel to the surface of the egg; at the same time there is an increase in the size of the cavity or

else the egg shrinks, so that there is considerable space between the egg and the upper part of the venter. The egg then generally contains large, perfectly spherical globules that stain deeply red with safranin; the shape suggests a fatty food substance. The breaking down of the canal cells leaves the egg invested with a great amount of striated mucilaginous substance which often fills more than half the venter (fig. 28). When the first division of the embryo occurs, all the cells of the venter have divided. Growth continues in the stalk, the venter, and the lower part of the neck until an extraordinary amount of tissue is developed about the embryo and the neck is greatly elongated, curving up above the cushion of the receptacle (fig. 29).

Sporogonium

The embryo develops in the usual way, beginning with a transverse wall. At first the seta appears as of considerable length when compared to the whole body (fig. 30), but later the capsule and foot develop more rapidly, so that the seta comes to be inconspicuous (figs. 31 and 33). The foot is well developed as an absorbing organ, the cells next to the thallus being large and slightly rhizoidal in shape. Just within the walls of these cells and of the adjoining cells of the thallus there is a granular deposition, probably related to the passage of nutrient material from the thallus to the parasitic sporogonium. The cells of the thallus respond to the invasion of the foot by dividing, as is shown by the cells nearest the foot being smaller than elsewhere. As the cells break down, a mucilaginous deposit remains, marking the limit between foot and thallus (fig. 32). As the sporogonium matures, the starch contained in the cells of the thallus near the foot disappears, and in all the cells of the receptacle it is scantier than in earlier stages.

The history of the development of the capsule and of the involucre, resembling the valves of a clam shell, has been described by LEITGEB. It might be added that a few cells at the base of the capsule remain sterile, but there is no regular elaterophore.

Summary

1. Two appendages may be present on the ventral scales.

2. Rhizoids are absent among the first pairs of ventral scales.

3. Old rhizoids are often replaced by new ones that form within them.

4. Fungi are prevalent in the compact tissue of the thallus. They enter through the rhizoids and may also pass out through them. No "pseudoparenchyma" was found.

5. The secretion of mucilage seems to have nothing to do with the "protection" of the growing point, but to be most pronounced about the egg and the antheridia.

6. Pitted cells show no tendency to become trachea-like.

7. The origin of air chambers in the thallus and receptacles is schizogenous. The horizontal increase in the size of the chambers is due to a tearing of the tissues. The pore of the chambers of the thallus and of the antheridial receptacle is simple, but that of the archegonial receptacle has an elaborate margin.

8. The development of the sex organs follows the Marchantiales type. The archegonia form early in the history of the receptacle and parallel the increase in size of the receptacle by great increase in length of the neck. Following fertilization an exceedingly massive venter is developed about the embryo.

9. Five archegonia may begin to develop on one receptacle, but no more than three come to maturity.

10. The condition of the cells of the foot and of the adjacent parts of the thallus indicate the parasitic nature of the sporogonium. No elaterophore appears.

Most cordial thanks are due Dr. W. J. G. LAND, who furnished the material for this study and followed the work with interest and encouragement.

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EXPLANATION OF PLATES I–IV

FIG. 1.—Sketch of monoecious thallus, dorsal view.

FIG. 2.—Sketch of thallus, ventral view.

FIG. 3.—Sketch of ventral scales with appendages.

FIG. 4.—Sketch of rhizoids; ×470.

FIG. 5.—Longitudinal section of an old rhizoid with a new one developing within.

FIG. 6.—Section of compact tissue by the thallus with fungal hyphae passing through the walls and destroying the protoplasm; ×450.

FIG. 7.—Fungal hyphae entering a thallus through a rhizoid.

FIG. 8.—Surface view of a pitted cell; ×687.

FIG. 9.—Vertical longitudinal section of a thallus through the apical cell, showing the origin of ventral scales (*s*) and air chambers (*a* and *b*); ×375.

FIG. 10.—Vertical section of developing air cavities in an archegonial receptacle; ×750.

FIG. 11.—Vertical section of an air pore of the thallus; ×667.

FIG. 12.—Vertical longitudinal section of a thallus with two archegonial receptacles and one antheridial.

FIG. 13.—Vertical section of a pore in an antheridial receptacle.

FIG. 14.—Vertical section of an early stage of an archegonial receptacle; ×67.

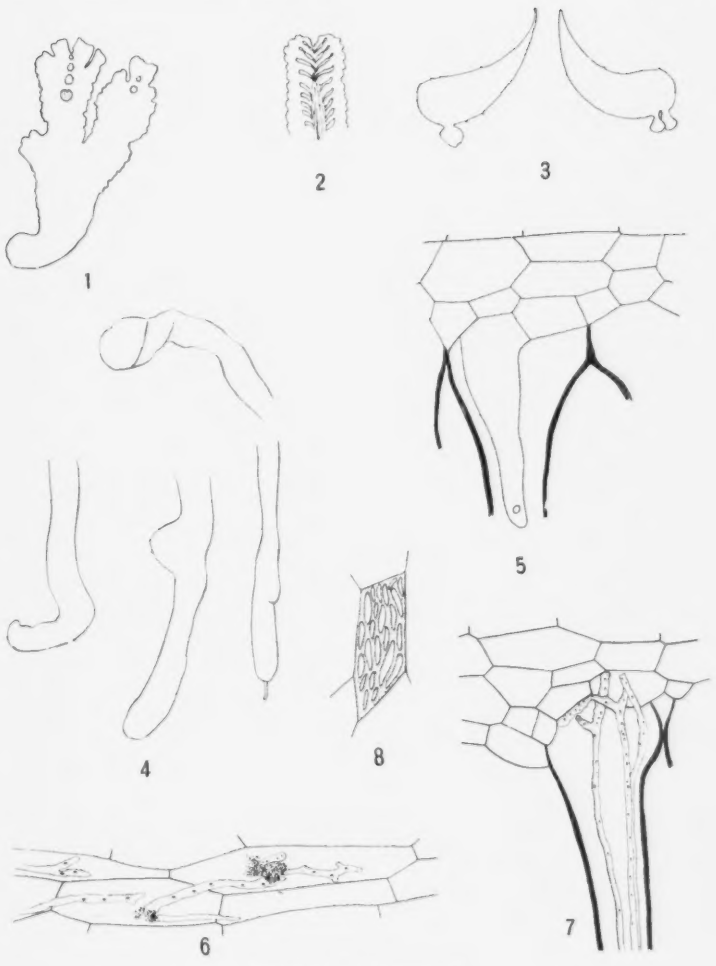
FIGS. 15–20.—Stages in the development of an air pore of the archegonial receptacle.

FIG. 21.—Surface view of an air pore of the thallus.

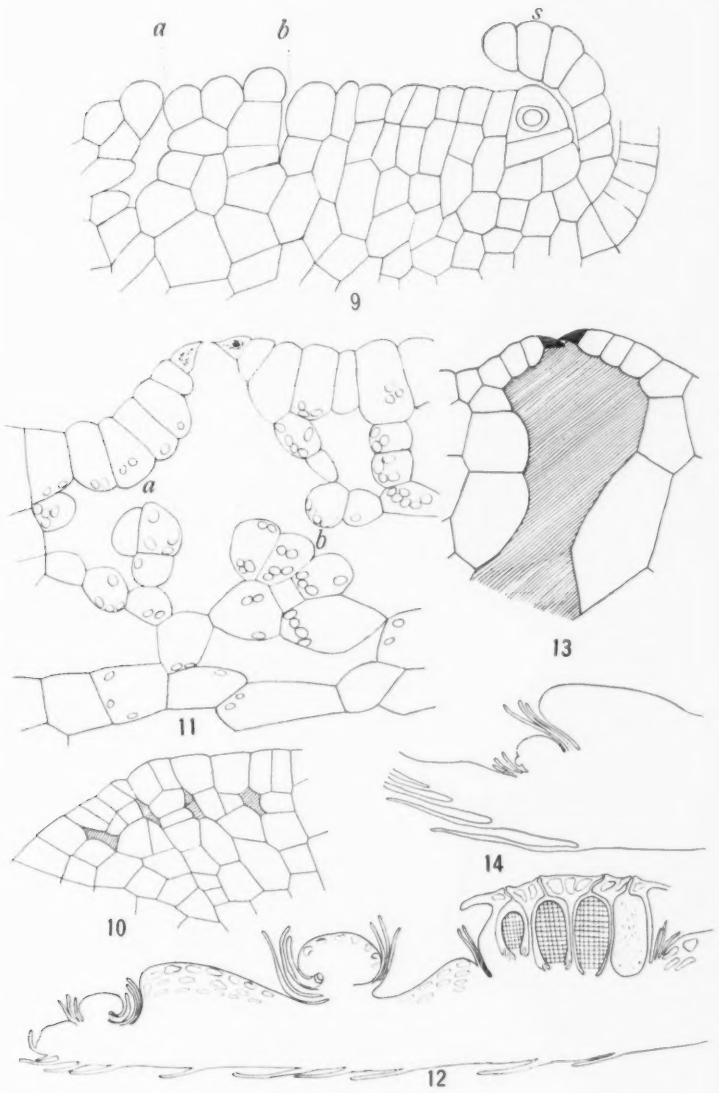
FIGS. 22–27.—Stages in the development of the archegonium before the formation of the egg; fig. 25 shows also the origin of a scale and of the involucre (*i*).

FIG. 28.—Vertical section of a venter after fertilization; *n*, nucleus; *g*, spherical globule; ×667.

FIG. 29.—Vertical section of an archegonium inclosing a young embryo; ×470.



STARR on AYTONIA



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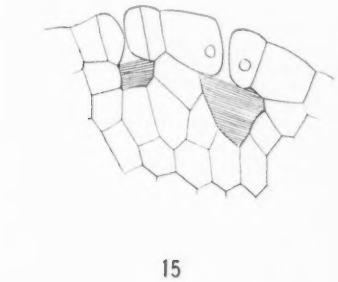

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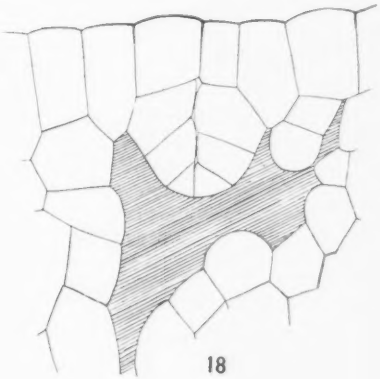

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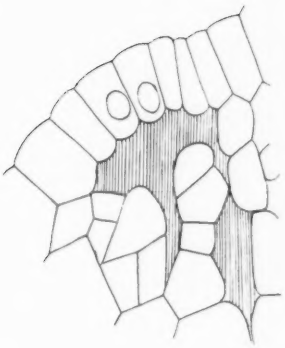

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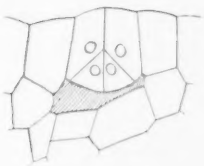

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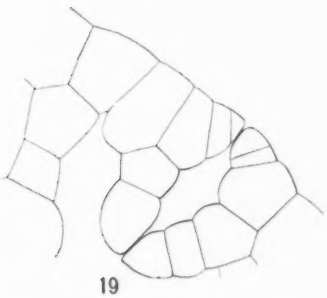

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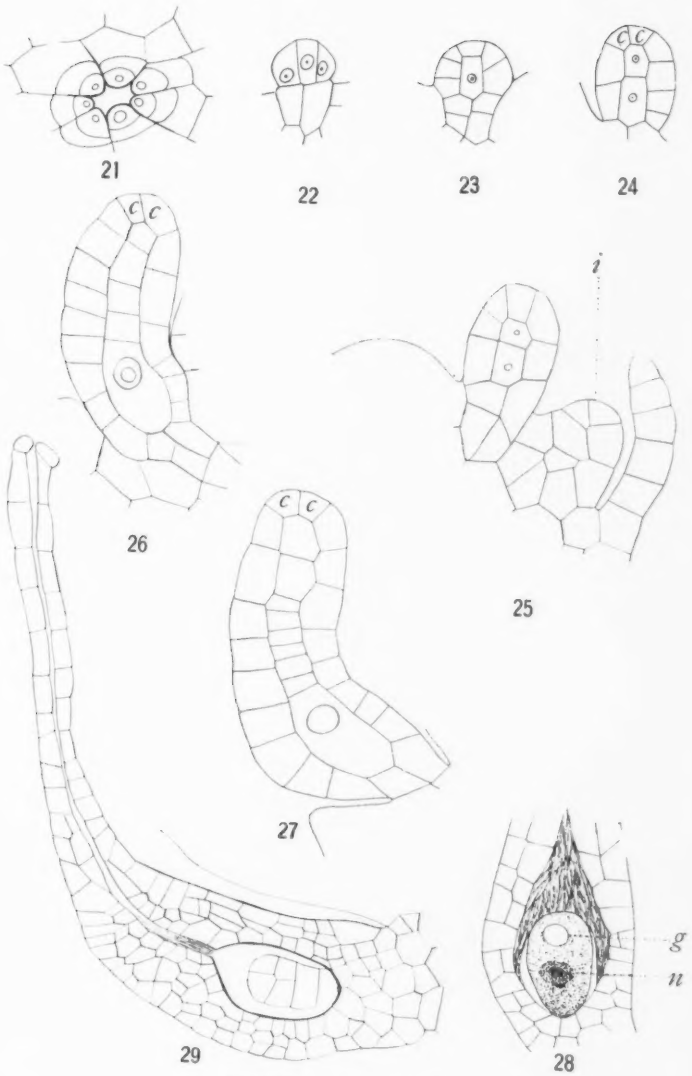
STARR on AYTONIA



STARR on AYTONIA

NOTES ON SUCCESSION FROM PINE TO OAK

BARRINGTON MOORE

Recent developments in the study of vegetative succession have changed ideas about the factors causing pine forests and oak forests. Formerly, even after the advent of the dynamic point of view, pine was supposed to grow only on sandy soils and oak only on soils containing clay. Now there is a strong tendency to consider pine as merely an earlier stage in the evolution from simpler associations to the climatic climax of the region, though the effect of the soil in hastening the process of evolution is recognized. The work in the region of the Great Lakes, particularly south of Lake Michigan,[1] has done much to bring this about. The ideas developed by these and other workers are widely disseminated through the literature dealing with vegetation and environment. But TAYLOR[2] has lately found, on the strength of geological facts which geologists admit are incontrovertible, and of phytogeographic evidence which appears at least convincing, that the pine barrens of New Jersey are not a new, but a very ancient, vegetation.

The attitude toward pine forests, therefore, may have to undergo revision. This does not mean necessarily that the work of COWLES and his associates is in error, but that possibly their conclusions have been too widely applied. It must be remembered that our knowledge of the factors which influence plants, especially of the

[1] COWLES, H. C., The physiographic ecology of Chicago and vicinity; a study in the origin, development, and classification of plant societies. BOT. GAZ. **31**:73–108, 145–182. 1901.

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WHITFORD, H. N., Genetic development of the forests of northern Michigan; a study in physiographic ecology. BOT. GAZ. **31**:289–325. 1901.

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———, Evaporation and soil moisture in relation to the succession of plant associations. BOT. GAZ. **58**:193–233. 1914.

LIVINGSTON, B. E., The relation of soils to natural vegetation in Roscommon and Crawford counties, Michigan. BOT. GAZ. **39**:22–41. 1905.

[2] TAYLOR, NORMAN, Flora of the vicinity of New York. Mem. N.Y. Bot. Garden **5**: 1915, especially pp. 8–25.

physics, chemistry, and bacteriology of soils outside of cultivated lands, and of the response of plants to their environment, is yet in a very rudimentary stage. Hitherto the tendency has been to consider one or two factors as an integration of many others, and to measure quantitatively only these two. For example, evaporation has been measured as an integration of all climatic factors, and soil moisture as an integration of all soil factors. It would not be surprising, therefore, if future progress should reveal some important factor which had been unavoidably overlooked. In view of the present uncertainty concerning the relation between pine and oak, the following notes on the pine and oak of Long Island may be of interest. They are based only on observation, without quantitative measurements, and lay no claims to definite conclusions.

The locality in which these observations were made is that part of the outwash plain about four miles east of Hempstead and four miles south of Hicksville. Here are found a number of different kinds of forests: a small body of pitch pine (*Pinus rigida* Mill.), practically untouched except for the usual fires, stands of mixed oak and pine, an oak forest, and more stands of pine. On this small area of not over 80 acres are exhibited more interesting problems than it has ever been the writer's good fortune to see on an area of the same size.

The first piece of forest which attracts attention is the body of pitch pine in its natural condition except for fires. The stand is composed of pure, even-aged pine, much damaged by fire. The trees, though about mature, as indicated by the flattening crowns, are only about 12 inches in diameter at breast height, by about 30 feet high. The understory is predominantly scrub oak (*Quercus nana* Sarg.), which is dense where the pine is open, diminishing where the canopy is more complete. In the scrub oak is a scattering of white oak (*Q. alba* Linn.), scarlet oak (*Q. coccinea* Moench.), black oak (*Q. velutina* Lam.), and post oak (*Q. minor* [Marsh.] Sargent). These oaks do not reach up into the main canopy and are short and limby. There was no pine reproduction, probably on account of the fires; fire-killed pine seedlings were found, and it is likely that many more had been entirely consumed.

The soil is a light brown, pebbly sand of coarse texture, with the upper 2–3 inches darkened by humus. The glacial origin of this soil is attested by the planed surfaces of the pebbles. In one place where the pine bordered an open field, a small piece, not over 50 by 100 feet, had been clear-cut sometime ago, perhaps 15 or 20 years. Here the ground has been taken possession of by aspen, on the field edge of which is a little gray birch (*Betula populifolia* Marsh.), considerable white oak and black oak, and a little post oak; scrub oak is mixed thickly with the aspen. The soil here was found to contain a considerable amount of clay or fine silty material.

That the clay or fine silty material is the cause of the aspen cannot be stated definitely, for the pine was there before the aspen, and might again take possession, as shown by pine seedlings on spots which had escaped fire. Furthermore, in another part of the forest, where the pine formed a fairly full stand except for occasional small openings made by trees which had been weakened by fire and then killed by insects, occur young aspen, gray birch, and sycamore (*Platanus occidentalis* Linn.). The soil here, at least down to 10 inches in depth, is the same coarse sand without clay as was found under the other parts of the pine forest; but, owing to the closer canopy of pine, there was a better mulch of needles, and a considerable quantity of humus in the first 4 inches of soil. It might be deduced that the extra mulch and humus here served the purpose of the clay, but it is dangerous to jump at conclusions from such observations. Clay might lie at various depths, being near enough to influence the vegetation in some places and not in others. Clay 2 feet below the surface would be sufficient to account for this second case of aspen and other deciduous trees. Judgment in this case must be withheld, therefore, until after further investigation.

Not far from this first body of pine, separated from it by a cultivated field, we find an open stand of pitch pine in which are scattered mature white oak trees, the understory being scrub oak. The white oak appears to be about the same age as the pine, but less numerous. The original stand, before fires became so frequent, was probably chiefly pine with a scattering of white oak. Here is what might appear at first sight to be an indication of

succession, the oak replacing the pine; but the soil, though still a coarse sand, has a distinct trace of clay which could account for the presence of the oak.

A short distance from the pine and scattering oak just noticed, we find an open stand of short limby white oak with an occasional pitch pine. There is an understory of scrub oak, which is, however, far less dense than on the areas where the pine predominates. To all appearances this could be another stage in the succession from pine to oak, a stage somewhat later than the one noticed just previously, for here the oak predominates instead of the pine, while the pine now occurs only sparsely, as the oak had done in the other place. This idea finds support in the first examination of the soil, which proves to be the same coarse sand as that found under the first forest of pure pine; but deeper digging shows that only the first 6 inches are sand, while below the sand is clay. This clay amply accounts for the presence of the oak, and probably the surface layer of sand accounts for the scattering pine.

Adjoining the white oak and scattered pine just described is a typical oak forest. The trees are scarlet oak and white oak, chiefly the former, with a little black oak, an occasional small hickory, and in certain parts of the forest a little chestnut oak (*Quercus prinus* Linn.). There is no chestnut (*Castanea dentata* Marsh.). One old pitch pine (probably about the same age as the oaks) and a pine stub, which could easily have been taken for relicts of a former pine forest, were seen. There is also a little pine reproduction which probably will not come up unless the canopy is opened.

The soil on which this oak forest is growing consists predominantly of clay or fine silty material. While not a very heavy soil, it was clearly one of moderately high moisture-retaining capacity. The precise nature of the differences between this soil and the coarse sand on which the pure pine was found cannot of course be stated without thorough analysis, but it is sufficiently clear that decided differences exist. This soil, so far as could be determined, strongly resembles that under the forest of oak with scattering pine, except that it lacks the surface layer of sand. It is significant that the layer of sand ends where the typical oak forest begins.

In this case, at least, the conclusion appears unavoidable that the occurrence of pine and oak is attributable largely, if not primarily, to the occurrence of distinctly different soils. This does not mean that the factors tending to bring about a succession from pine to oak are absent, but merely that these factors appear in this case to be distinctly subordinate to the character of the soil. Only the most thorough quantitative investigation can begin to unravel all the factors involved, and final conclusions cannot be expected until further progress has been made in the sciences on which the investigation must be based, particularly in plant physiology and in physics, chemistry, and bacteriology of soils, all of which deal with the phenomena which go to make up the vegetative cover as we find it.

There is in this same locality another kind of succession, different from the physiographic one[3] above referred to; this is a succession started by the interference of man.[4]

At the edge of the oak forest above described was found a patch of young pitch pine about 20 years old. The soil proved to be more gravelly than under the oaks, but with still a considerable proportion of clay or fine silty material. It might appear offhand from this that the clays do not necessarily support oaks; but the true explanation fails to corroborate this idea, and is very simple. Further examination revealed old, almost obliterated furrow marks, showing that this land had formerly been cleared and cultivated. That it originally supported oak was indicated by a strip of oak standing between the pines and a field still used for growing hay, and still further by a sharp line of demarcation between an old forest of oak and the young pine. There is but little scrub oak among the pines, and the better oaks, scarlet oak, black oak, and white oak, are coming in on the edges. It is obvious, therefore, that the pine is merely a temporary cover which has taken possession of the land after the oaks had been completely cleared off (not merely clear-cut), and the land later abandoned. If further evidence that pine is a forerunner of the forest on cleared and

[3] COWLES, H. C., A textbook of botany. Vol. II. Ecology, p. 940. New York. 1911; also citations under note 1.

[4] ———, *op. cit.*, p. 958.

abandoned land in this locality were needed, it is furnished by a few seedlings of pine in the neighboring hay field.

The indications are that this entire locality was once covered with pine, and that on the better soils (those with more clay) the pine soon gave way to oak. Unquestionably the oak stage was reached on these better soils many years ago, probably not long after the oak forest had become established on the near-by hills to the north. But when, through the interference of man, the oaks are completely destroyed, as in clearing land for farming, and when the land is again abandoned, pine takes possession. The reason is probably to be found in the more rapid methods of seed dissemination possessed by the pine as compared with the oaks. This would account for the presence of gray birch, and occasionally aspen, on lands beginning to revert to forest.

When the forest is cut for wood, and the stumps are left to coppice, the pine has another but far less favorable opportunity to establish itself. From observations on other areas, it seems that after cutting, provided no fire occurs, a considerable number of pine seedlings come in, but with a few exceptions are unable to develop on account of the more rapidly growing oak sprouts. The exceptions are probably seedlings which happen to grow in larger openings among the sprouts, or near old stumps which fail to sprout. Such exceptions readily account for the pines which, as noted above, might have been considered as relicts in the oak forest; for this forest, or rather the generation preceding it, had unquestionably been cut over for wood some 50 years ago.

It is evident then that we have here two forms of pine forest: (1) a temporary form which will be replaced by an oak forest in a comparatively short time, roughly 150–300 years or possibly longer, depending a great deal on the size of the area; and (2) another form of which much less is known. The temporary form occurs on soils containing clay; the other form on sands. The question is: Will this second form occurring on sands be replaced by oaks through an amelioration of edaphic conditions brought about by the pine forest itself? The tendency, on the strength of all the quantitative investigations of the subject to date, would be to answer yes. Such an answer would be most unfortunate in creating a bias in

future investigations; and it is just this feature of the situation which needs emphasis. Conclusions from one locality should not influence investigations in another locality, except in creating a desire to test the conclusions. The answer should be: We do not, and cannot, know until after thorough quantitative study of all factors which so far as now understood may have a bearing on the question.

Meanwhile, until such an investigation is made, several features of the situation, so far as they can be determined by observation without detailed study, may be noted. It is conceivable that, if conditions were left undisturbed for a sufficient length of time, the pine would, by a gradual accumulation of humus, render the soil favorable to the oaks,[5] which would then crowd out the pine. But in nature, conditions, at least in forests, are never left undisturbed indefinitely, for if man does not start fires lightning will, and fire tends to produce a deadlock between the pine and the oak. It favors the oak against the pine in that the oak seedlings which are killed can come up again from sprouts, whereas the pine seedlings cannot. On the other hand, it favors the pine against the oak by destroying the physical conditions, especially the litter and humus,[6] favorable to the oak. The result is that a worthless form of oak, the scrub oak (*Quercus nana*), which both is fire-resistant and can grow on sandy soil, takes possession of the ground. Above the scrub oak is seen an occasional pine or an oak, most frequently a white oak, owing to its greater power of fire-resistance.

It might be noted here that the scrub oak, owing to its dense habit of growth, protects the soil against leaching out, as well as serving as an excellent accumulator of humus. It appears to be analogous to the snowbrush and manzanita in the northern and central Sierras of California. These species and their associates, which should not be confused with the true chaparral farther south, form a dense cover of brush about 4–8 feet high, which keeps the soil and lower atmospheric strata favorable for the establishment

[5] By oaks is meant the forest-forming species, not the scrub oak (*Quercus nana* Sarg.).

[6] It has been found by R. C. HAWLEY by quantitative experiments that repeated fires actually burn not only the surface mulch, but the humus which is in the soil.

of the white fir (*Abies concolor*). This tree, owing to its ability to endure shade, persists under the brush, eventually forces its way through, shades out the brush, and reestablishes forest conditions. The difference is that the region in question possesses no trees as tolerant of shade as the white fir. At the same time, the scrub oak is never as dense as the Sierra brush, and offers in between clumps openings in which the pine or better oaks can come up. The pine, owing to its wider area of seed dissemination, has more opportunity than the oaks to take advantage of these openings, provided seed trees remain. On the other hand, the oak, when once it starts, stands a better chance of becoming established on account of its power to sprout after being killed by fire.

The foregoing, though by no means covering the whole case, seems sufficient to show that the problem of succession so far as pine and oak are concerned is extremely complex. It is of the utmost importance that each case be considered by itself. So many complex and interacting factors, such as the previous history of the region (as emphasized by TAYLOR), the surrounding vegetation, and the soil and moisture conditions, enter into each case that the conclusions of one locality may be wholly misleading when applied to another locality only a few miles distant.

NEW YORK CITY

THE PATHOLOGY OF ORNAMENTAL PLANTS

MEL. T. COOK

The rapid development of plant pathology in America has resulted in giving a far better understanding of the diseases of certain groups of plants than of others. While we find a rather extensive literature on diseases of field crops, fruits, and vegetables, we find a very meager literature on the diseases of ornamental plants.

In that period which preceded the rise of plant pathology the mycologists devoted their attention primarily to the study of the taxonomy, morphology, and life history of the parasite, and it must be admitted that the work of these men was superior in many ways to much of that which has come from the more recent students in the new school of plant pathology.

The treatment of plant diseases was the first real step in plant pathology following the work in taxonomic mycology, but with the advance of the subject it soon became evident that the plant pathologist should give a great deal of attention to the symptoms and progress of the diseases. This involves a knowledge of the physiology of both the host and the parasite, and also a knowledge of the chemistry of the plant and of the fungicides to be used.

The efforts of the plant pathologists were very naturally directed to those crops which produced food and clothing, and more especially to those crops which required a maximum amount of personal attention on the part of the grower. Consequently, we find a rapid advancement of the science in the studies of the diseases of fruits and vegetables, closely followed by studies on field crops, forest trees, and shade trees.

The apparent neglect of the diseases of ornamental plants is due to three causes: (1) most people do not look upon ornamental plants as being of economic importance; (2) many of the growers of ornamental plants have received little or no satisfaction from the plant pathologist and have therefore developed many methods which they frequently hesitate to make public; (3) the plant

pathologist frequently finds the work with ornamental plants unsatisfactory and complicated by physiological problems and difficulties which make the returns uncertain.

1. The growing of ornamental plants is of very great importance and involves millions of dollars annually. The most casual observer must be impressed by the large number of greenhouses in the vicinity of large cities, the great quantities of cut flowers displayed in city markets, and the fine plantings in public gardens and parks. To these must be added the private conservatories and gardens.

2. It is very evident that plant pathologists are not well informed concerning the diseases of ornamental plants and therefore cannot give as ready answers to the inquiries from the growers as they can to the growers of other kinds of plants, and for reasons stated in topic 3 find the study of diseases of ornamentals unsatisfactory. Furthermore, pathologists usually have all they can attend to in studying the diseases of fruits, vegetables, and field crops. The growers of ornamentals have many empirical rules for their work, some of which are very carefully guarded. However, when we find them mistaking fungus spots on leaves and stems for scale insects and treating their plants with insecticides when they should be treated with fungicides, we begin to realize that studies and publications along this line are very necessary.

3. This work falls into two divisions, outdoor and indoor plants. In the first of these we know very little beyond the treatments for chrysanthemum rusts and mildews, and a very few other diseases. The root diseases, which are carried back and forth between the greenhouses and the outdoor plots and which are frequently intensified by the fertilizers, present some of the most profitable lines of research. These problems very naturally blend to some extent into the seed bed and truck crop problems.

The indoor problems are by far the most complicated and the most difficult. Some of them are influenced by the character of the fertilizers, and by very slight variations in temperature, humidity, sunlight, and air currents. They are in many respects problems in physiology rather than pathology. It also occurs that two related varieties may require slightly different environmental conditions to protect them from the same parasite. However, many of the

problems of the greenhouses are comparatively simple, but require the service of trained men to bring about their solution. The difficulties in this work are also increased by the fact that many of the greenhouses are large instead of being properly partitioned into smaller apartments, and that numerous varieties of plants are kept in single large apartments. It will be readily seen that many of these problems merge into the problems involved in the growing of winter vegetables under glass.

There is a prevailing belief in many places that plant pathology must be confined to the agricultural colleges and experiment stations. But here is a line of investigation which can be carried on to advantage by other institutions, many of which are much better prepared to do the work than are the agricultural colleges and experiment stations. Many of our large universities are located in or near large cities and can get in close contact with ornamental plant industry; they can choose their own lines of work instead of such lines as may be dictated to them by the constituency of the agricultural colleges and experiment stations; they are frequently provided with far better mycological collections than are found in the above-named institutions; they have good corps of workers in taxonomy, morphology, and physiology, and are well prepared to investigate the various phases of the problems involved. If these institutions feel the necessity of giving a comprehensive course in plant pathology, they will find an abundance of material in the orchards and truck farms of the vicinity and in the local fruit and vegetable markets for every phase of work except the treatment of diseases. There is still another phase of the work which must prove very interesting and profitable to the departments of botany in our large universities, and that is the study of the fungi which are brought in on tropical plants and which persist unknown to many of our northern botanists.

RUTGERS COLLEGE
NEW BRUNSWICK, N.J.

BRIEFER ARTICLES

EDWARD LEE GREENE

(WITH PORTRAIT)

In the passing away of Dr. EDWARD LEE GREENE we have lost one of our most eminent botanists. As a correspondent writes: "A gap is thus made in the ranks of American botanists that can never be filled. His investigations during his long period of activity have added greatly to the knowledge of North American plants." His death occurred in Providence Hospital, Washington, D.C., November 10, 1915, after a long illness. He was born in Hopkinton, Rhode Island, in 1843, and was therefore seventy-two years old at the time of his death. He graduated from Albion College, in Wisconsin, in 1866, and was educated for the ministry, being for fourteen years an Episcopal clergyman. In 1885, however, he gave up his parish and joined the Catholic church. From 1885 to 1895 he taught botany in the University of California. From 1895 to 1904 he was professor of botany in the Catholic University of America, at Washington, D.C.; and from 1904 until his death was associate in botany in the United States National Museum. He served his country during the Civil War and was a member of the Grand Army of the Republic.

From photograph by Bachrach, Washington, D.C.

For many years he was simply a collector of plants, sending his specimens to others to name or describe, although occasionally he sent

short notes to botanical publications, one of which was published in this journal as early as 1876. About 1888 he began to write extensively, describing especially new genera and species, and this he continued without interruption until the time of his death. The number of species which he has described may safely be estimated at considerably over 3000.

For many years he was a vigorous advocate of nomenclature reform, and while many of his ideas were good, he was always considered radical and he had few if any disciples. He had extreme views on the limitations of species, which led someone to describe him as a second RAFINESQUE, a sobriquet which sometimes pleased and sometimes irritated him, depending on his mood. He was indeed a man of many moods and fancies; was often shy but never timid; always had many friends and many enemies. He was egotistical, sometimes to the point of being ludicrous, and yet to many of us who knew him well he was always a delight and an inspiration. He was fond of music and cards, was a charming host, and a welcome guest in many homes. He lived a quiet life, usually alone with his pets, often doing his own cooking and housework. He was wont to take long walks alone in the fields and woods. In early life he tramped over a good part of Colorado and California in search of rare plants. He loved plants for their own sake and grew many of the wild flowers in his garden. He was a keen observer, and as he was so familiar with plants in their native haunts, his observations and conclusions were always worthy of consideration.

Dr. GREENE's education had been thorough, his knowledge of the classics profound, and of the early botanical writers simply marvelous. His botanical writings, while extensive, were chiefly made up of short papers. He preferred to write strong forceful reviews, to monograph small genera, or to publish a few pages of new species. His early papers on the botany of the Pacific Islands are little gems. He delighted in coining original and striking generic names, like *Lilaeopsis* and *Ibervillea;* he was original in everything he did. His style was often quaint, but pure. The names of his publications were often unique and have often been imitated. His full bibliography would fill several pages of this journal. This will doubtless be prepared and published later; but his most important works were *Pittonia*, a series of papers relating to botany and botanists (five volumes); *Leaflets* (two volumes); *The West American oaks;* and *The landmarks of botanical history*. His "Carolus Linnaeus," an address delivered on the two-hundredth anniversary of the birth of LINNAEUS, is one of his best short papers. In December, 1914,

he began a new serial, *Cybele Columbiana*, but only one number appeared. His name is commemorated in the genus *Greenella* and in many specific names.—J. N. ROSE, *Smithsonian Institution, Washington, D.C.*

THE POLLINATION OF ASCLEPIAS CRYPTOCERAS

(WITH ONE FIGURE)

Asclepias cryptoceras is one of the largest flowered asclepiads of the Rocky Mountain region, and although it has a large range over Colorado, Utah, Wyoming, and Idaho, it is seldom common. It is not easily forgotten when once seen growing on a loose, barren hillside, with its deep red and pale green flowers, with their wonderful fragrance and bizarre form, resembling nothing so much as a jewel in a setting. Because of this peculiarity of structure I propose the vernacular name of "jewel milkweed" as being appropriate. The unusual form is of course due to peculiar insect relations.

The general mechanism of a milkweed flower is well known and a brief recapitulation is all that is necessary here. The asclepiadaceous flower appears externally to consist of the usually reflexed petals and sepals and of the so-called "column," which is surrounded by five "hoods" out of which usually arise five hornlike processes. Between the hoods and on the side of the column are five slits which are usually wedge-shaped, having the larger and open end toward the bottom of the column. The small black bodies which are visible externally at the upper end of the slits are known as corpuscula, and to them are fastened by means of hidden bands the adjacent pollen masses or pollinia of two neighboring anther cells, one on either side of the slit. A corpusculum may be likened to a paper clip and has a wedge-shaped opening on the lower end.

In order that an insect may effect pollination it is necessary for it to wedge its foot in the slit of the column when climbing about over the flower or scrambling to reach the nectar in the hoods. This is usually not a difficult thing to do, and when once it is caught a sharp pull is necessary to extricate the foot. When the insect is free we find, if we examine its leg, a corpusculum firmly fastened to it by means of the cliplike arrangement, and to the corpusculum we find the pollinia attached. If the insect now goes on with its work of gathering nectar, it is usually not long until it is again caught in the slit. This time it draws into it the pollinia previously obtained and with another vigorous pull it breaks the bands connecting the pollinia with the corpusculum and escapes. The pollinia left in the slit are now in contact with the stigmatic surface. By these processes pollination is effected.

The jewel milkweed differs from the typical asclepiad in several important respects. The flowers are nodding instead of erect, and, as a direct adaptation to this, the hoods are closed except for a small opening at the apex; the horn is small and included or hidden within the hood; the lips of the slit are firmly closed, and instead of offering an easy entrance to their trap seem to make the entrance difficult. In many kinds of milkweed the hoods and the upper part of the column are borne on a pedicel several millimeters in length. The hoods are sessile in *Asclepias cryptoceras*.

The pollination of the jewel milkweed, in southwestern Colorado at least, is apparently accomplished by only one species of insect, a huge bumblebee (*Bombus Morrisoni* Cressn.).[1] This huge bee is a full match for the large flower, yet it has a rather difficult time obtaining the nectar. Since the flowers are nodding and since the pedicel is absent, there are no footholds offered, and the bumblebee must continually scramble to keep its position. The hoods guide its feet to the slits, and the bee forces them open, and in order to free itself loosens the corpusculum and drags out the pollinia firmly fastened to its feet. When they dry they are in a convenient position to enter the next slit that chances to open in the bee's scrambling for a foothold.

The fragrance of the flowers is so intense that one would imagine many insects would be attracted, yet such is not the case. In my observation of this plant during the spring of 1914 in southwestern

[1] My thanks are due Professor COCKERELL of the University of Colorado for the determination of this species.

Colorado, I saw but few insects visiting the flowers except the species of bumblebee mentioned. Occasionally a fly or a bee would alight on them, but was capable neither of obtaining nectar nor of dislodging the pollinia. The bumblebees, however, on warm spring days, were actively at work on them; there was no hesitation in their work; they knew where the honey was stored and how to get it. I found pollinia and corpuscula attached to the legs of all bumblebees I caught on *Asclepias cryptoceras*.—
EDWIN PAYSON, *University of Wyoming, Laramie, Wyo.*

CURRENT LITERATURE

BOOK REVIEWS

Mesozoic plants

The present contribution[1] is a continuation of the admirable catalogues of mesozoic plants, published from time to time, by the authorities of the British Museum. One notes with pleasure in the 350 odd pages and over 30 plates that the anatomy of the forms discussed is somewhat fully dealt with. Excluding algae and fungi, which have been described in a previous volume, the authoress begins with the ferns, the most interesting of which is the genus *Tempskya*, illustrated mainly from the Russian species *T. rossica*, recently figured for both habit and anatomy by KIDSTON and GWYNNE-VAUGHAN.

The Cycadophyta are represented by species of *Bennettites*, *Cycadeoidea*, and a new genus *Colymbetes*, all showing vegetative structure and anatomically illustrated. *Cycadeoidea* and *Colymbetes* are of great interest because they manifest the reduplication of the vascular ring so common in living cycads, but hitherto not described for *Bennettites* and its allies.

In the case of the conifers, a number of woods as well as a few twigs and cones are described. In the course of her descriptions of woody coniferous structures, the writer devotes herself frequently to somewhat caustic criticisms of the reviewer's anatomical publications on mesozoic conifers. Significantly enough she describes no araucarian woods for the Greensand. These important conifers seem to have had practically no anatomical representatives in the Lower Cretaceous and the Jurassic, an interesting fact for those who accept the orthodox view that the conifers have originated from the Cordaitales through the araucarian line. Dr. STOPES'S interesting if not convincing point of view can perhaps as well be illustrated from her references to the genus *Sequoia* of the Mesozoic, as otherwise. Dr. HOLLICK and the reviewer have brought forward anatomical evidence from the study of correlated external form and internal organization that the supposed sequoias of the American Mesozoic are in reality araucarian conifers, and do not belong at all to the genus which they superficially simulate. Dr. STOPES admits that our material is not *Sequoia*, and this is at first sight an indication of rare and pleasing open-mindedness, but we are surprised to learn that the mesozoic remains universally included under *Sequoia* and *Geinitzia* by competent American systematic paleobotanists are in reality wrongly referred to those genera and do not cor-

[1] STOPES, Dr. MARIE, British Museum catalogue of mesozoic plants. Part 2. Lower Greensand (Aptian) plants of Britain. London. 1915.

respond with the similar European forms. This attitude appears to be of very dubious value indeed, in view of the completeness of the agreement never before questioned between the American genera and even species and those of Europe as long recognized by distinguished students of both floras. This position in regard to American supposed mesozoic sequoias and their European counterparts is not the less surprising in view of the meagerness and bad state of preservation of her material, in contrast to the abundance and perfection of that from American deposits.

The volume closes with anatomical descriptions of the woody dicotyledonous genera *Cantia*, *Woburnia*, *Sabulia*, *Hythia*, and *Aptiana*, which present no feature of interest beyond vouching anatomically for the presence of the dicotyledons in the early Cretaceous.—E. C. JEFFREY.

Hydrogen ion concentration

MICHAELIS[2] is the author of the first of a series of *Monographs on plant and animal physiology*. The series, which is edited by CZAPEK and PARNAS, is to bear somewhat the same relation to its realm as the well known *Monographs on biochemistry* bear to their more restricted field. Many of the proposed numbers promise to be of the greatest interest to plant physiologists. The present volume deals with hydrogen ion concentration, its significance in biology, and the methods for measuring it. In the introduction the author points out the importance of the "actual" reaction of the medium in determining the course of chemical changes in organisms, and cites instances of the misinterpretation of experimental results due to failure to consider this factor.

The monograph is divided into three parts. In the first the theoretical significance of hydrogen ion concentration is discussed. Following a development of the general principles and formulae for the dissociation of water, acids and bases, and amphoteric electrolytes, these are applied to the special cases of proteins and enzymes. By combining the results of experiments on the influence of hydrogen ion concentration on enzyme activity, and the results of transfer experiments on the same enzymes, some interesting conclusions are drawn as to the chemical nature of the enzymes studied. Invertase, for instance, is considered an amphoteric electrolyte of which only the undissociated part of the "invertase acid" is effective, and only the cations of pepsin are effective in hydrolyzing proteins.

The second part of the monograph is a statement of present knowledge as to the hydrogen ion concentration at which physiological processes go on in organisms, the variations of this factor that occur, and the means the organism possesses for regulating the acidity of its body fluids. In general, if a body fluid is characterized by a specific enzyme, the hydrogen ion concentration of the fluid corresponds to the optimum for that enzyme. The variations are

[2] MICHAELIS, L., Die Wasserstoffionenkonzentration, ihre Bedeutung für die Biologie und die Methoden ihrer Messung. Berlin. 1914.

usually small. The reaction is regulated by the salts of weak acids and bases present, and by the removal of acids by the lungs and kidneys.

The methods for measuring hydrogen ion concentration are taken up in the third part. Those based on the measurement of reaction velocity are omitted, as they are practically useless in biological work. The gas chain method is treated very thoroughly from the theoretical and practical points of view, and the formulae and tables given make the book an excellent laboratory guide for carrying out these measurements. The discussion of the indicator method is somewhat less complete. Methods for preparing solutions of a definite hydrogen ion concentration, a method for carrying out transfer experiments with colloids, and a complete bibliography are appended.

The work done in this field has been limited almost entirely to animal processes. Undoubtedly this factor is of importance in the plant as well, and investigations in this direction should furnish valuable additions to our knowledge of plant processes.—THOMAS G. PHILLIPS.

NOTES FOR STUDENTS

Current taxonomic literature.—O. AMES (Philipp. Jour. Sci. Bot. **9**:11–16. 1914) under the title "Orchids of Guam" has published 8 new species.—H. ANDRES (Oesterr. Bot. Zeits. **64**:232–255. 1914) in continuation of his studies on the Pirolaceae records further important data on this group.—G. ARNAUD (Bull. Soc. Myc. France **30**:355–360. *pls. 17–19.* 1914) in an article discussing the genus *Henriquesia* characterizes a new genus (*Castagnella*) of the Dothideaceae, which is found on branches of *Quercus coccifera*.—E. G. BAKER (Jour. Linn. Soc. **42**:241–246. *pls. 9–14.* 1914) gives a synopsis of the "African species of *Crotalaria*." The author recognizes 309 species, several of which are new to science.—I. W. BALFOUR and W. W. SMITH (Notes Roy. Bot. Gard. Edinb. **8**:191. 1914) have published a new genus (*Kingdonia*) of the Ranunculaceae from China.—H. H. BARTLETT (Cybele Columbiana **1**:37–56. *pls. 1–5.* 1914) characterizes 12 new elementary species of *Onagra*.—O. BECCARI (Webbia **4**:293–385. 1914) under the title "Studio sui Borassus" includes the description of a new genus of palms (*Borassodendron*) based on *Borassus Machadonis* Beec. from the Malayan Peninsula.—R. E. BENEDICT (Bull. Torr. Bot. Club **41**:291–410. *pl. 20.* 1914) presents a revision of the genus *Vittaria* in which 7 species are recognized, 2 being new to science.—A. BENNETT (Philipp. Jour. Sci. Bot. **9**:339–344. 1914) records one new species of *Potamogeton* and a new hybrid from the Philippine Islands.—A. BÉQUINOT and N. BELOSERSKY (Atti de' Lincei.—Mem. Cl. sc. fisiche ecc. Ser. 5ª. **9**:595–734 [1–144]. *pls. 1–12.* 1913) have published a monographic revision of the genus *Apocynum*, recognizing 26 species of which 4 from the eastern United States are described as new.—E. P. BICKNELL (Bull. Torr. Bot. Club **41**:411–427. 1914) in continuation of his studies on the flowering plants of Nantucket includes the Clethraceae, Pyrolaceae, and Ericaceae. New species are recorded

in *Hypopitys* and *Vaccinium*.—G. BITTER (Abh. Nat. Ver. Brem. **23**:114–163. 1914) in continuation of his studies on the Solanaceae describes a new species of *Grabowskia* (*G. Sodiroi*) from Ecuador.—J. W. BLACK (Trans. & Proc. Roy. Soc. S. Australia **37**:1–5. *pl. 1*. 1913) describes and illustrates a new genus (*Pectinella*) of the Potamogetonaceae, a salt water plant of Australia. The same author (*ibid.* 121–124. *pls. 4, 5*) under the title "Additions to the flora of South Australia" characterizes a new genus (*Griffithia*) of the Compositae.—S. F. BLAKE (Jour. Bot. **52**:169. 1914) has published a new *Chimaphila* (*C. domingensis*) from Santo Domingo.—F. BOEDEKER (Monatschr. für Kakteenk. **24**:52–55. 1914) describes and illustrates a new cactus (*Mamillaria Gürkeana*) from Mexico.—L. BOLUS (Ann. Bolus Herb. **1**:20, 21. 1914) has described a new genus (*Pillansia*) of the Iridaceae, based on *Tritonia Templemanni* Baker of Cape Colony.—G. BONATI (Bull. Soc. Bot. Genève II. **5**:297–316. 1914) has published several new species of the Primulaceae, Solanaceae, and Scrophulariaceae, and includes a description of a new genus (*Centrantheropsis*) of the last family.—F. Borgesen (Dansk Bot. Ark. **2**:1–66. 1914) in an article entitled "The marine algae of the Danish West Indies. Part 2. Phaeophyceae" includes the descriptions of several new species and one new genus (*Rosenvingea*).—J. BRIQUET (Ann. Conserv. et Jard. Bot. Genève **11**:326–403. 1914) under the title "Decades plantarum novarum vel minus cognitarum" has published upward of 50 new species of flowering plants mostly from Mexico and South America.—N. L. BRITTON (Bull. Torr. Bot. Club **41**:1–24. 1914) under the title of "Studies of West Indian plants" has described 26 new species.—N. E. BROWN (Bull. Kew 1914, p. 156) has published a new species of *Chamodora* (*C. nana*) indigenous to Costa Rica. The same author (*ibid.* 168) records a new genus (*Metaporana*) of the Convolvulaceae from Africa, and (*ibid.* 208) describes a new species of *Cotyledon* (*C. paraguayensis*) from Paraguay.—F. BUBÁK (Bot. Közlemények **13**:94–96. 1914) describes and illustrates a new genus (*Moeszia*) of the Hyphomycetes, found on leaves of the oak at Budapest, Hungary. The same author (Ann. Mycologici **12**:205–220. *pl. 8*. 1914) under the title of "Beitrag zur Pilzflora von Tirol und Istrien" has described several new species of fungi and proposes the following new genera: *Basilocula, Cystodendron, Stigmopsis, Piricanda*, and *Verticilliodochium*.—B. F. BUSH (Am. Mid. Nat. **3**:352, 353. 1914) has published 2 new species of *Antennaria* from Missouri.—E. J. BUTLER and A. H. KAHN (Mem. Dept. Agr. India **6**:181–208. *pls. 1–6*. 1914) on "Some new sugar cane diseases" include the description of a so-called "collar rot" to which is given the scientific name *Hendersonia Sacchari* Butl.—J. CARDOT (Rev. Bryol. **41**:37, 38. 1914) has described a new moss to which he gives the generic name *Philibertiella;* it is related to *Ditrichium*.—R. CHODAT (Bot. Jahrb. **52**, Beibl. no. 115. pp. 70–85. 1914) under the title "Polygalaceae novae" has published 30 new species of *Polygala* of which about one-half are from Mexico, Central and South America.—C. CHRISTENSEN (Am. Fern Jour. **4**:77–83. 1914) describes two new American species in *Dryopteris* and records further data toward his

monograph of this genus.—L. DAMAZIO (Bull. Soc. Bot. Genève II. **6**:171–172. 1914) describes and illustrates a new fern (*Elaphoglossum Beauverdii*) from central Brazil.—C. DE CANDOLLE (Bull. Soc. Bot. Genève II. **6**:107–126. 1914) describes new species in *Piper*, *Cabralea*, *Gaurea*, *Cedrela*, and *Begonia* from Paraguay. The same author (Not. Syst. **3**:38–44. 1914) has published several new species of *Piper* and *Peperomia*, including 4 from Mexico, and (Rep. Sp. Nov. **13**:304–311. 1914) describes 16 additional species in these genera from Bolivia.—L. DIELS (Philipp. Jour. Sci. Bot. **8**:157–158. 1913) has published three new species of Menispermaceae from the Philippine Islands.—S. T. DUNN (Notes Roy. Bot. Gard. Edinb. **8**:153–171. 1913) in an article entitled "Notes on Chinese Labiatae" describes several species new to science and proposes a new genus, namely *Parlamium*, based on specimens collected in Yunnan by Mr. HENRY.—A. ENGLER (Bot. Jahrb. **51**:225–471. 1914) in cooperation with several specialists has published "Beiträge zur Flora von Afrika xliii." Approximately 200 new species and varieties of flowering plants are described, and the following new genera are proposed: *Rhodohypoxis* Nel of the Amaryllidaceae, *Melliniella* Harms of the Leguminosae, *Gilgiochloa* Pilger of the Gramineae, and *Neosloetiopsis* Engler of the Moraceae.—A. W. EVANS (Bull. Torr. Bot. Club **41**:577–616. *pl. 21*. 1914) under the title "Report on the Hepaticae of Alaska" includes the description of two new species of *Plagiochila* and one of *Radula* from Alaska.—J. S. GAMBLE (Philipp. Jour. Sci. Bot. **8**:203–206. 1913) under the title "Some additional bamboos of the Philippine Islands" records further data concerning this group of plants and adds a new species from Mindanao.—L. S. GIBBS (Jour. Linn. Soc. **42**:1–240. *pls. 1–8*. 1914) under the caption "A contribution to the flora and plant formations of Mount Kinabalu and the highlands of British North Borneo" has published an important contribution to our knowledge of the flora of Borneo. Prominent specialists have cooperated in the identification of the plants and upward of 80 species are described as new to science. The following new genera are proposed: *Phyllocrater* and *Cowiea* Wernham of the Rubiaceae, *Sigmatochilus* Rolfe of the Orchidaceae, and *Lophoschoenus* Stapf of the Crepyaceae.—J. M. GREENMAN.

Phenomena of parasitism.—Differences in the behavior of *Monilia cinerea* and *Botrytis cinerea* are brought out by the studies of COOLEY and of BROWN. These fungi represent the two sections of the genus *Sclerotinia* the members of which have frequently furnished material for investigations designed to throw light on the phenomena of parasitism. While the apothecial organs of these fungi are much alike, their conidial fructifications are widely different; but more interesting from a biological standpoint is the difference in the mode of formation of sclerotia with which the contrasting behavior brought out in the two papers can perhaps be correlated. COOLEY,[3] who investigated the be-

[3] COOLEY, J. S., A study of the physiological relations of *Sclerotinia cinerea* (Bon.) Schröter. Ann. Mo. Bot. Gard. **1**:291–326. 1914.

havior of *Monilia* (*Sclerotinia*) *cinerea* with reference to its parasitism, finds that the spores are incapable of infecting young green plums whose skin is uninjured, but that such fruits are easily attacked by grown mycelium applied to their surfaces. The ripening fruits, however, are readily infected through the unbroken skin by spores. The acidity of the fruit, the author finds, increases as ripening progresses. The fungous hyphae penetrate the fruit in all directions, but they do not follow the middle lamellae, nor is there a general disintegration of the host tissue due to the action of the fungus on the middle lamellae. From histological observations it appears that the host cells are not injured in advance of the penetrating hyphae. The observation that the juice of much decayed plums had no cytolytic action on the flesh of sound plums seems to be in accord with the observation on the action of the hyphae themselves, yet it can scarcely be doubted that if a sufficiently concentrated extract of the young mycelium had been prepared, more positive results would have been obtained, for, as the author himself states, it is probable that the juice was too dilute to be effective. Other objections to the use of the juice of decayed fruit are obvious. In agar tubes containing cellulose prepared from the plums by different methods, very slight action on the cellulose was observed, but filter paper cellulose was readily dissolved. In tubes containing pectin a coagulation was produced by *Monilia*, but in tubes containing suspensions of calcium pectinate without soluble carbohydrates the fungus made little growth and the pectinate was not hydrolyzed. In expressed fruit juices in which the fungus had grown, oxalic acid was found in small quantities, and also in peaches inoculated with *Monilia*, but not in others inoculated with *Penicillium* and *Aspergillus*. The fungus grows best in acid media.

BROWN[4] investigated the less strictly parasitic fungus *Botrytis cinerea*. By using large quantities of germinating spores, he was able to prepare extracts whose enzymatic activity was much greater than that of the extracts used by DEBARY, WARD, and others who investigated the cytolytic action of extracts of this or closely related species of *Botrytis*. The extracts prepared by BROWN brought about a rapid disintegration in the tissues of roots, tubers, fruits, leaves, and petals of various plants. Thin discs (1–1.25 cm.×0.5 mm.) of potato, turnip, beet, apple, etc., were disorganized in 15–90 minutes. The tissues of bryophytes and filaments of algae appear not to be affected. The process of disorganization begins with solution of the middle lamella, as a result of which the tissue loses its coherence. Finally, the cell wall itself is disintegrated and the tissue is completely disorganized. The death of the cells does not take place until some time after the cells have been separated by the solution of the middle lamella. The activity of the extract is destroyed by heat and by shaking, the toxic action being destroyed simultaneously. When the extract was dialyzed by means of collodion thimbles, the dialysate showed

[4] BROWN, W., Studies in the physiology of parasitism. I. The action of *Botrytis cinerea*. Ann. Botany **29**:313–348. 1915.

neither cytolytic nor toxic activity, nor did it contain any trace of oxalic acid or oxalates to which the toxic action of *Botrytis* extract has sometimes been attributed. The enzyme acts only in acid media. In neutral solution its activity is greatly retarded, and in slightly alkaline media the activity is inhibited. Here again the toxic properties of the extract are affected in the same manner as the cytolytic properties. The extract may be reactivated by the addition of acid to the neutralized or alkaline medium. From the impossibility of separating, by any of the means described above, the toxic and the cytolytic properties of the extract, the author is inclined to believe that both are due to the same substance or group of substances.

The most striking difference in the physiological behavior of these two fungi is seen in the extent of their cytolytic action. By reason of its greater virulence in this respect, *Botrytis cinerea* is adapted to live as a saprophyte on dead plant tissues poor in soluble carbohydrates, while *Monilia*, possessing the power of hydrolyzing cellulose only to a slight extent, is restricted in its existence to ripening fruits and other tissues rich in soluble sugars. Correlated with this difference in the mode of life of the two fungi is the method of production of sclerotia. The tissues invaded by *Botrytis* are completely destroyed, consequently the sclerotia are formed as well defined free bodies outside of the invaded substance, while in *Monilia* the sclerotia are formed within the mummified tissues of the host, which are sometimes involved in the process.—H. HASSELBRING.

Notes on gymnosperms.—THOMAS[5] has discovered the staminate strobilus of *Williamsonia gigas* from the Jurassic of Yorkshire. The strobilus consists of 18–20 microsporophylls united into a cuplike structure. THOMAS is inclined to believe that these sporophylls were not associated with the ovule-bearing region, but that they represent an independent staminate strobilus.

SAHNI[11] has discovered in the pollen chamber of some young ovules of *Ginkgo* certain winged pollen grains which are very different from those of *Ginkgo*. About a dozen such ovules were examined, and 8 contained these foreign pollen grains, characterized by prominent wings. Furthermore, not only did these ovules contain foreign pollen from as many as three distinct species, but one of the pollen grains was in an advanced stage of germination. The interesting suggestion is made that if a similar example were found in a fossil, "it would in all probability lead to a reference of the pollen grains and ovules to the same species." Since this has been done already, the caution is well taken.

[5] THOMAS, H. HAMSHAW, On some new and rare Jurassic plants from Yorkshire: the male flower of *Williamsonia gigas* (Lind. and Hutt.). Proc. Cambridge Phil. Soc. **18**:105–110. *pl. 6. figs. 2.* 1915.

[6] SAHNI, BIRBAL, Foreign pollen in the ovules of *Ginkgo* and of fossil plants. New Phytol. **14**:149–151. *pl. 2.* 1915.

PEARSON[7] has been studying the morphology of *Gnetum*, and has recorded some interesting observations. He finds four types of strobili in *G. Gnemon*, which constitute a sequence from the strictly monosporangiate to the bisporangiate condition. He also finds that the endosperm develops in many details as that of *Welwitschia*, especially in the multinucleate character of the primitive tissue. The nuclei in each "compartment" in the chalazal region fuse; while in the micropylar region there is no septation. It seems, therefore, that the primary endosperm of the two genera is alike in all respects. PEARSON sees in this endosperm a new structure which is neither sporophyte nor gametophyte, but which he designates as "trophophyte," and it is further suggested that the endosperm of angiosperms is a highly specialized form of this trophophyte. The interesting suggestion is made that the fusing polar nuclei of angiosperms may be morphologically the representatives of the fusing nuclei of *Welwitschia* and *Gnetum*.

BOODLE[8] has discovered concrescent leaves on a tree of *Pinus Laricio* growing in the Royal Botanical Gardens, Kew. These leaves are produced every year in considerable numbers. It is suggested that the double needles of *Sciadopitys* may be morphologically similar to those of *P. Laricio*, that is, they may represent two foliage leaves fused by their margins. The orientation of the leaves of the double needles of the Austrian pine, however, is not constant, cases being found with fusion by the adaxial margins, by the abaxial margins, and by obliquely placed leaves.—J. M. C.

Endemic flora of Ceylon.—In connection with the revision of his catalogue of the Ceylon flora, WILLIS[9] has reached some interesting conclusions in reference to geographical distribution and evolution. The conclusions are derived from the use of statistical methods and the classification of the Ceylon species into a series of six groups, graded from "very rare" to "very common." He observes that the rarest plants are local endemics, and the commonest are those of widest distribution. The conclusion is that "local endemic species have not been developed in any kind of advantageous response to local conditions." That the endemic genera should show greater rarity than do the endemic species as a whole cannot be explained by any such theory of adaptation. Graphically WILLIS' observations would "run in the exact reverse direction all through to that demanded by the theory of natural selection." A second conclusion is that on the average the commonness of the species depends upon its age locally, species developing "quite indifferently to local conditions, though possibly because of those conditions."

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[7] PEARSON, H. H. W., Notes on the morphology of certain structures concerned in reproduction in the genus *Gnetum*. Jour. Linn. Soc. **43**:55–56. 1915.

[8] BOODLE, L. A., Concrescent and solitary foliage leaves in *Pinus*. New Phytol. **14**:19–22. *figs. 4*. 1915.

[9] WILLIS, J. C., The endemic flora of Ceylon, with reference to geographical distribution and evolution in general. Phil. Trans. Roy. Soc. London B **206**:307–342. 1915.

WILLIS suggests that all Ceylon species have arisen as single mutations, and that subgenera and genera may arise similarly. Some of the endemics of Ceylon, which are and always have been very restricted, would indicate that the same mutation need not go on appearing in order to become established. However well a species may be locally adapted, it will be in great danger of extermination until it has gotten beyond the degree of commonness represented by "very rare." "Having reached the maximum height [in the scale of commonness] that it is going to reach, a species will ultimately descend, and will sooner or later become extinct, though there is no evidence that as yet many or any species are on the downward road." The statistical facts brought out "support very strongly the hypothesis that the whole tree of descent of a family may exist on the earth at the present moment, and that the area occupied is in general an indication of the age of a species or a genus, if it has not already attained its maximum."—MERLE C. COULTER.

The mosaic disease of tobacco.—ALLARD[10] has given an account of the mosaic disease of tobacco that will be of much interest to all who desire to become acquainted with the chief features of this interesting and destructive disease. The most characteristic external feature of the disease is a mottling of the leaf, due to partial chlorosis. The disease is communicable to a number of the Solanaceae, but appears to be distinct from the very similar mosaic disease of *Phytolacca*. The mosaic virus permeates all parts of the plant, but does not infect the embryo; hence seeds of diseased plants produce healthy individuals. The disease seems to be incurable and no plants of susceptible species seem to be immune. The origin and distribution of the disease are mysterious, and the author's experiments lead him to oppose the more commonly current theory that the disease is associated with unbalanced enzymatic activities and physiological toxins. ALLARD thinks that the disease is parasitic and that it is communicated from plant to plant by certain aphids. No organisms that might be responsible for the disease have yet been isolated. This disease seems to have the characteristics of infectious chlorosis, as described by BAUR.

Further studies of the mosaic disease, also by ALLARD,[11, 12] have to do with interesting special features. It is found that the dilution of the virus to 1 part in 1000 results in no impairment of infection, though dilution to 1 part in 10,000 results in an effective attenuation of the virus activity. While the

[10] ALLARD, H. A., The mosaic disease of tobacco. U.S. Bureau of Plant Industry, Bull. 40. pp. 33. *pls.* 7. 1914.

[11] ———, Effect of dilution upon the infectivity of the virus of the mosaic disease of tobacco. Jour. Agric. Research 3:295–299. 1915.

[12] ———, Distribution of the virus of the mosaic disease in capsules, filaments, anthers, and pistils of affected tobacco plants. Jour. Agric. Research 5:251–255. *pl.* 1. 1915.

virus does not permeate to the embryo if has been traced to the ovule integuments.—H. C. COWLES.

Leaf anatomy of Veronica.—The xerophytic, shrubby species of *Veronica* indigenous to New Zealand have long excited the interest of ecologists, and now they have been made the subject of a careful anatomical study by ADAMSON.[13] He investigated 39 species, the material being obtained from plants grown in England, although comparison was made with herbarium material. Most of the species are indigenous to the eastern part of the southern island where the rainfall and temperature are low and the wind high. While these species seem admirably fitted for life in such a climate, they show remarkably little plasticity in cultivation. Six ecological groups are recognized as follows: (1) with the large or elongated, not particularly xerophytic, leaves; (2) with leaves similar in aspect, but thick and leathery; (3) with small, spoon-shaped, somewhat xerophytic leaves; (4) with leaves similar in form, but much more leathery and often glaucous; (5) with leaves much reduced and either small and spreading or appressed and imbricate; (6) with leaves toothed and petioled. The most characteristic xerophytic structural features are reduction of leaf surface and of intercellular spaces and high cutinization. In some of the more xerophytic forms there are curved cuticular expansions arching over the stomata, forming an outer vestibule. Hydathodes, usually more characteristic of hygrophytes, are found in some of these species. In general, the increasing xerophytism noted in the first five groups above is correlated with increasing xerophytism of habitat, culminating in the famous whip-cord species, which show a striking resemblance to certain conifers.—H. C. COWLES.

Upper cretaceous and eocene plants.—Only the points of interest to botanists need be considered in this contribution by BERRY.[14] In the cretaceous flora the author describes a number of conifers and angiosperms. In the case of the former, he records his belief that the material identified by HOLLICK and described anatomically by the reviewer as species of the recognized mesozoic *Sequoia*, do not in reality belong to this genus. This is a most interesting statement in view of the fact that some of the reviewer's specimens came from and were identified by BERRY himself. Dr. STOPES in her recent continuation of the catalogues of mesozoic plants of the British Museum, being in possession of some of the reviewer's material, admits that it does not belong anatomically to the genus *Sequoia*. There thus arises a very interesting situation indeed. What BERRY systematically identifies as *Sequoia* is according to Dr. STOPES anatomically not *Sequoia* at all. One wonders if the paleobotanists of the Mesozoic will be as slow to admit that they may be deceived by the external

[13] ADAMSON, R. S., On the comparative anatomy of the leaves of certain species of *Veronica*. Jour. Linn. Soc. Bot. **40**:247–274. *figs.* 17. 1912.

[14] BERRY, E. W., The Upper Cretaceous and Eocene floras of South Carolina and Georgia. Professional paper 84, U.S. Geol. Survey. 1915.

form of their material as were formerly their confreres of the Paleozoic, who needed nearly a hundred years to recognize that many of the arboreal forms of the carboniferous forests were not seed plants but vascular cryptogams, a view long urged by the anatomists and finally admitted on every hand. The flora of the Middle Eocene of Georgia is chiefly interesting because of the fact that it clearly marks, in the opinion of the author, a warmer climate for that epoch than for the early Eocene.—E. C. JEFFREY.

Phylogenetic taxonomy of angiosperms.—Professor BESSEY for many years was interested in a phylogenetic scheme of classification, especially with reference to the angiosperms. In a series of papers he has developed his point of view, and his final paper was presented in connection with the twenty-fifth anniversary celebration of the Missouri Botanical Garden.[15] An interesting feature of the paper is the definite formulation of the principles of classification as applied to flowering plants. These principles are given in the form of 28 "dicta," 7 of them of general application, and the remainder having special reference to flowering plants. These dicta announce the primitive and derived condition in reference to numerous structures, some of them generally accepted, and some of them under discussion. The author then applies these numerous dicta to the taxonomic complexities of angiosperms. He substitutes "Oppositifoliae" and "Alternifoliae" for the old names dicotyledons and monocotyledons, on the theory that dicotyledons are primitively opposite-leaved, as shown by their cotyledons; and by the same sign monocotyledons are essentially alternate-leaved. With this start, and in this way, the whole sequence of angiosperms is presented in 300 families, beginning with Alismataceae and ending with Lactucaceae (the Compositae being presented as 14 families). It is a very laborious assembling of material on the basis of assumed phylogenetic sequences, quite comparable with Engler's *Syllabus*, and useful in the same way.—J. M. C.

Amoeboid movements of chromatophores.—The large epidermal leucoplasts of mature leaves of *Orchis latifolius* and *O. incarnatus*, according to KÜSTER,[16] display amoeboid changes of form, having the power to put out and take in processes resembling pseudopodia. Also these leucoplasts at times break up into a large and small portion, which in turn may again fuse. KÜSTER does not accept the idea of SENN that there is a peristromium surrounding the chromatophore, holding rather that the pseudopodia belong to the chromatophore itself. Sometimes the chromatophore as a whole moves in the direction taken by a pseudopodium, thus exhibiting active movement. More commonly, however, a leucoplast suffers no change in position, following a pseudopodial

[15] BESSEY, CHARLES E., The phylogenetic taxonomy of flowering plants. Annals Mo. Bot. Gard. **2**:109–164. *fig. 1.* 1915.

[16] KÜSTER, ERNST, Über amöboide Formveränderungen der Chromatophoren höherer Pflanzen. Ber. Deutsch. Bot. Gesells. **29**:362–369. *figs. 4.* 1911.

movement. KÜSTER believes that the usual movement of chromatophores is passive, these organs being carried in the direction of protoplasmic streaming, whatever the direction taken by the pseudopodia. From these studies it is concluded that the chromatophores in question are fluid. It is suggested that other chromatophores, as those in *Listera* and *Iris*, may have the characteristics of the *Orchis* chromatophore.—H. C. COWLES.

Parthenogenesis in Nicotiana.—GOODSPEED[17] has made some very interesting experiments in connection with parthenogenesis in *Nicotania*, suggested by a strain of *N. Tabacum* in which Mrs. R. H. THOMAS reports parthenogenesis. Over 500 attempts to produce parthenogenetic seed from a number of species and varieties of *Nicotiana* yielded negative results. These experiments included crossing and propagation through several generations. In the case of the parthenogenetic strain referred to, however, approximately 800 experiments resulted in over 100 normally matured fruits. In the majority of these parthenogenetic fruits empty seeds were produced in great numbers, and for this type of seed production, either with or without pollination, GOODSPEED suggests the term "phenospermy," referring to the seed condition usually described as "abortive" or "empty." Approximately 50 seeds occurred in nine of the parthenogenetic fruits, some of which showed mature endosperm and embryos. A small proportion of the seed from the parthenocarpic fruits was neither parthenogenetic nor phenospermic, but contained traces of endosperm only.—J. M. C.

Bactericidal substances.—That the juices of plants may contain bactericidal substances which figure in protecting the plants against the attacks of certain organisms has been shown by WAGNER.[18] Varying numbers of bacteria of the non-parasitic species *Bacillus vulgatus*, *B. asterosporus*, and *Bacterium putridum* were injected into the tissues of potato tubers, beet roots, and the leaves and roots of *Sempervivum Hausmanii*. The injected organisms proved parasitic only when present in enormous numbers (3000–8000), and in that case were able to bring about the decay of the injected tissues. When injected in smaller numbers, the bacteria are destroyed. In case of the potato and of *Sempervivum*, the freshly expressed juice was found to possess bactereolytic and agglutinating properties, but from the sugar beet no bactericidal juice could be obtained. The active substances were found to be contained in the protein fraction of the juice. When the fresh filtered juice containing enzymes, carbohydrates, and salts is allowed to stand for two days, its bactericidal power is destroyed, probably by the action of oxidases and other enzymes.—H. HASSELBRING.

[17] GOODSPEED, THOMAS H., Parthenogenesis, parthenocarpy, and phenospermy in *Nicotiana*. Univ. Calif. Pub. Bot. 5:249–272. *pl. 35*. 1915.

[18] WAGNER, R. J., Über bakterizide Stoffe in gesunden u. kranken Pflanzen. 1. Mitteilung: Die gesunde Pflanze. Centralb. Bakt. II. 42:613–624. 1914.

Rafflesia and its host.—BROWN[19] has made a study of the relation of *Rafflesia manillana* to its host, a species of *Cissus*. It is parasitic on the roots, the base of the flower being imbedded in a vase-shaped mass of tissue formed from the root of the host. The vegetative portion of *Rafflesia* consists for the most part of rows of cells, which occur in the xylem, medullary rays, cambium, phloem, and sclerenchyma of the host. The flowers originate from rows of cells which usually cross the cambium. The presence of the parasite causes an excessive growth of both the xylem and the bark of the host, resulting in the formation of the vase-shaped mass of tissue in which the base of the shoot is imbedded. The differentiation of the growing point takes place before the shoot breaks through the bark of the host, but the enlargement of the parasite finally produces cracks in the bark, through which the parasite grows.—J. M. C.

Sex determination.—WILSON[20] has studied material of *Mnium hornum* in which an axis bears heads of "mixed organs" and also female heads. Some of the organs resembled antheridia, others archegonia, while a complete series of intermediate forms also occurred. Since the spermatogenous cells of the normal antheridia possess six chromosomes, the normal gametophyte number, the plant could not have been produced aposporously. The conclusion is suggested that sex determination is not bound up with mitosis, but is brought about "by metabolic processes which operate in the organism over a considerable part of its life history." This relation between the sexual condition and the conditions of living is a point of view which is becoming more and more established as the facts of sexuality accumulate.—J. M. C.

Cladophora in deep water.—In studying certain curiously corroded limestone slabs, known locally as "honeycomb rock," occurring in the deeper waters of Lake Ontario, KINDLE[21] found some of them covered by a green alga. Since these specimens were obtained from a depth of 150 feet, the determination of the alga was of considerable interest. Upon reference to COLLINS and BRAND, the alga proved to be *Cladophora profunda* Brand, a species occurring in the lakes of the Bavarian highlands, but at no greater depth than 15 meters. BRAND characterized the Lake Ontario material as "forma *ima*." The species has not been recorded hitherto in America, and the depth at which it occurs is three times as great as any before known.—J. M. C.

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[19] BROWN, W. H., The relation of *Rafflesia manillana* to its host. Phil. Jour. Sci. Bot. **7**:209–226. *pls. 12–21.* 1912.

[20] WILSON, MALCOLM, Sex determination in *Mnium hornum*. Ann. Botany **29**: 443–440. *pl. 20.* 1915.

[21] KINDLE, E. M., Limestone solution on the bottom of Lake Ontario. Amer. Jour. Sci. **39**:651–656. *figs. 3.* 1915.

Monograph of Senecio.—In 1902, GREENMAN published the first part of a monograph of the North and Central American species of *Senecio*.[22] The second part, beginning the synoptical presentation of species, has now appeared.[23] Two subgenera are recognized: *Eusenecio* Hoffm. and *Pseudogynoxis* Greenm., the latter including the single section CONVOLVULOIDEI. Not only are the full bibliography and descriptions of each species given, but exsiccatae are cited freely, particularly such as occur in American herbaria. In the present part 32 species are presented, representing 5 of the 22 sections. Two new species are characterized, namely *S. Townsendii* from northern Mexico and *S. hypotrichus* from central Mexico.—J. M. C.

Carboniferous plants.—This memoir[24] consists of 150 pages and 30 superb plates, which are far superior to anything we are accustomed to find in geological publications on this side of the Atlantic. The authoress devotes herself to the study of the plants of the well known reefs containing paleozoic plant remains which lie to the west of St. John. She points out that the forms represented in the ledges are distinctly carboniferous, and as a consequence the view of Sir WILLIAM DAWSON, which has been followed by many others, that these deposits are of Devonian age, can no longer be maintained. In her attitude in this respect she agrees with WHITE of the United States Geological Survey.—E. C. JEFFREY.

Trees of Texas.—LEWIS[25] has published an illustrated manual of the native and introduced trees of Texas, intended chiefly for those who do not have access to the more technical manuals. The descriptions are much simplified, and this fact, together with the numerous illustrations, should bring the woody plants of Texas within easy reach of all those who are interested in them. Over 200 species are included, *Quercus* being much the largest genus, with 25 species.—J. M. C.

Malayan ferns.—Capt. VAN ALDERWERELT VAN ROSENBURGH[26] has described 73 new Malayan ferns, representing 23 genera. The genera represented by 5 or more new species are as follows: *Pleopeltis* (10), *Dryopteris* (8), *Polypodium* (8), *Phegopteris* (7), *Hemitelia* (5), *Hymenophyllum* (5), *Lindsaya* (5). In addition to the ferns new species are described in *Lycopodium* (3) and *Selaginella* (21).—J. M. C.

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[22] Engl. Bot. Jahrb. **32**:1–33. 1902.

[23] GREENMAN, J. M., Monograph of the North and Central American species of the genus Senecio. Part II. Ann. Mo. Bot. Gard. **2**:573–626. *pls. 17–20.* 1915.

[24] STOPES, Dr. MARIE, The fern ledges' carboniferous flora of St. John, New Brunswick. Department of Mines, Geol. Survey of Canada. Memoir 41. 1915.

[25] LEWIS, ISAAC M., The trees of Texas. Bull. 22. Univ. Texas. pp. vi+169. *figs. 48.* 1915.

[26] VAN ROSENBURGH, Capt. C. R. W. K. VAN ALDERWERELT, New or interesting Malayan ferns 6. Bull. Jard. Bot. Buitenzorg **10**: no. 16. pp. 60. *pls. 10.* 1914.